



Biological Assessment Report

East Fork Black River Macroinvertebrate Community Assessment

Reynolds County, Missouri

Fall 2017 and Spring 2018

Prepared for the
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program

Prepared by the
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1.0 Introduction

1.1 Purpose of Bioassessment Study

The Missouri Department of Natural Resources (**MoDNR**) Water Protection Program directed the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) to conduct follow-up monitoring on East Fork Black River (**EFBR**), water body identification number (**WBID**) 2737, in accordance with an Ameren Taum Sauk Federal Energy Regulatory Commission (**FERC**) license. East Fork Black River is classified in the Missouri Water Quality Standards (**WQS**) as a class P stream with the designated uses of Livestock and Wildlife Watering, Protection of Warm Water Habitat, Whole Body Contact, and Drinking Water Supply (MDNR 2018f).

In December 2005 the Upper Taum Sauk Reservoir failed and released roughly a billion gallons of water over a few minutes, scouring the East Fork Black River downstream. The Bioassessment Unit of the WQMS has periodically collected samples on the EFBR since 1999. Previous work by the WQMS is discussed later in this report.

The goal of this study was to assess water quality based on stream habitat, water chemistry, and macroinvertebrate communities in East Fork Black River, Reynolds County, Missouri. To address this goal, four stations were sampled: one station upstream of the Highway 21 bridge at Lesterville (**EFBR #1**), one station in the vicinity of Wicks Cave near Lesterville (**EFBR #2**), one station downstream of the Lower Taum Sauk Reservoir Dam (**EFBR #3**), and one station in the restored river reach in Johnson's Shut-Ins State Park (**JSISP**) (**EFBR #6**) (Figure 1). Samples were collected on September 25-26, 2017, and March 20-21, 2018. Tasks included the analysis of habitat parameters to compare with biological criteria reference (**BIOREF**) habitat conditions, water chemistry analyses to determine trends related to the macroinvertebrate community, and bioassessment of the macroinvertebrate community to infer biological integrity.

1.2 Null Hypotheses

- H₁: Habitat scores will not differ among stations.
- H₂: East Fork Black River habitat scores will not differ from the BIORREF habitat scores.
- H₃: Physicochemical parameters will not differ among stations.
- H₄: Physicochemical water quality parameters will meet Missouri WQS.
- H₅: Physicochemical water quality parameters will not exceed U.S. Environmental Protection Agency (**EPA**) nutrient criteria.
- H₆: The Macroinvertebrate Stream Condition Index (**MSCI**) will indicate benthic communities are similar among stations.
- H₇: Station MSCI scores will show no improvement over the total period of sample collections.

2.0 Study Area

The East Fork Black River drainage is dominated by deciduous forest cover with minimal urban and impervious surface influences (Table 1). This same trend is present in the BIOREF stream (Sinking Creek, Reynolds County) drainage and in the Ozark/Black/Current Ecological Drainage Unit (EDU). Grasslands make up a higher percentage of land cover in the reference and Ozark/Black/Current EDU than in EFBR.

Table 1. Percent Land Cover in the East Fork Black River (EFBR) Study Drainage in Comparison to the Reference Stream and the Ozark/Black/Current EDU Drainage.

Land Cover	Hydrologic Unit Code 12		Ozark/Black/ Current EDU
	EFBR Stations	Reference Stream	
	11010007030002	110100070504	
Impervious	0.3	0.4	0.6
High intensity urban	0	0	0
Low intensity urban	0.1	0	0.4
Barren or sparsely vegetated	0.2	0.4	0.3
Cropland	0.1	0.3	0.9
Grassland	3.8	9.8	23.9
Deciduous forest	83	80.3	66.8
Evergreen forest	1.8	1	2
Mixed forest	0	0	0
Deciduous woody/herbaceous	7.9	4	3.5
Evergreen woody/herbaceous	0	0	0
Woody-dominated wetland	1.1	3.4	0.9
Herbaceous-dominated wetland	0	0.4	0.2
Open water	1.7	0.2	0.5

Notes: EDU = Ecological Drainage Unit.

3.0 Station Descriptions

East Fork Black River Station #1 (EFBR #1) (SE ¼ sec. 16, T. 32 N., R. 2 E.) was the most downstream station on East Fork Black River and was located immediately upstream of the Highway 21 bridge in Lesterville, Missouri. Geographic coordinates of the downstream terminus of the sampling reach are in Universal Transverse Mercator (UTM) coordinates as UTME 692107, UTMN 4147245.

East Fork Black River Station #2 (EFBR #2) (NW ¼ sec. 9, T. 32 N., R. 2 E) was located in the vicinity of Wicks Cave, north of Lesterville, Missouri. Geographic coordinates collected near the midpoint of the sampling reach are UTME 691135, UTMN 4149194.

East Fork Black River Station #3 (EFBR #3) (SW ¼ sec. 33, T. 33 N., R. 2 E.) was located downstream of the Lower Taum Sauk Reservoir spillway. Geographic

coordinates of the upstream terminus of the sampling reach are UTME 691167, UTMN 4151896.

East Fork Black River Station #6 (EFBR #6) (NW ¼ sec. 16, T. 33 N., R. 2 E.) is the restored river reach within Johnson's Shut-Ins State Park, located downstream of Highway N. Geographic coordinates of the upstream terminus of the sampling reach are UTME 690586, UTMN 4157636.

Sinking Creek #1 (SC1) (SW1/4 sec. 26, T. 30 N., R. 2 E.) is the biological reference stream used as a habitat comparison to EFBR stations. Geographic coordinates of the sampling reach are UTME 694202, UTMN 4123917.

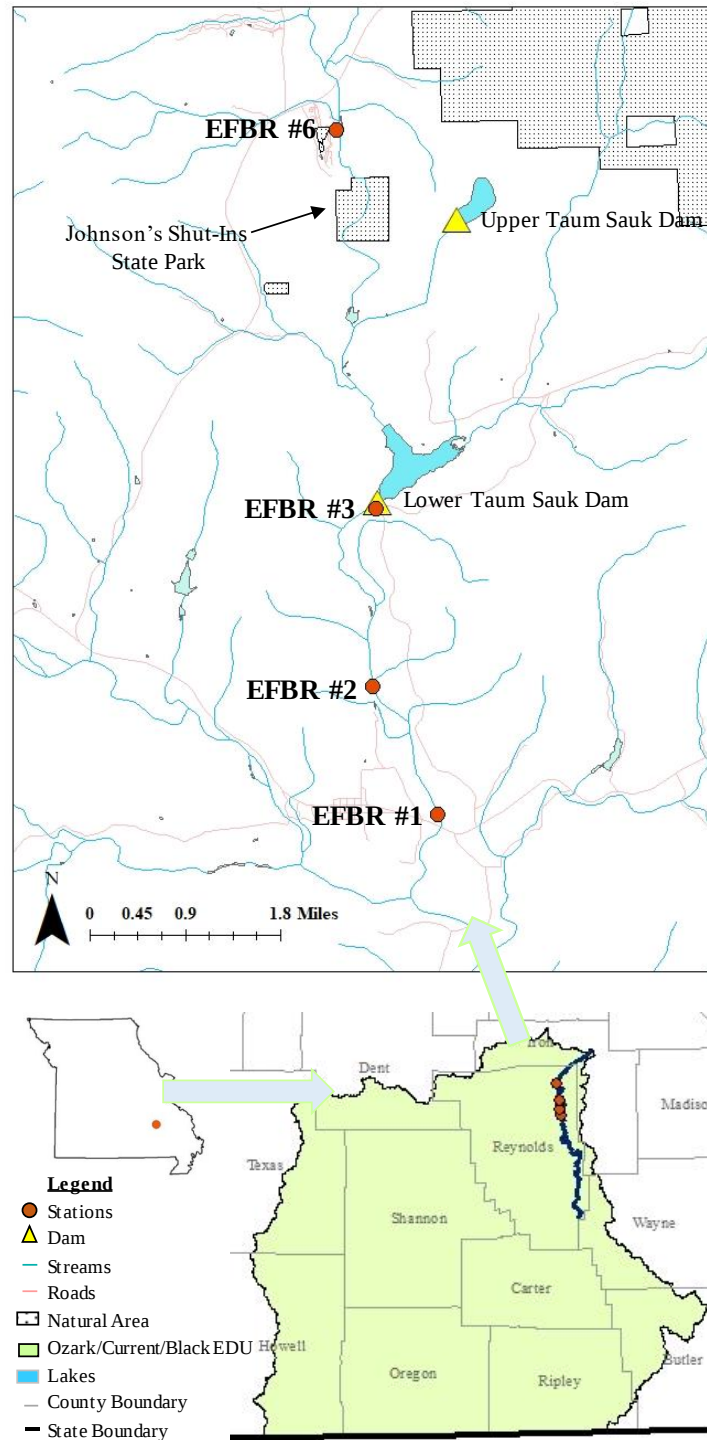


Figure 1. Stations on East Fork Black River, Reynolds County, Missouri.

Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-In State Park.

4.0 Methods

4.1 Stream Habitat

Stream habitat is a foundational filter for aquatic communities and as such determines which species can be supported. Stream habitat was assessed using procedures for riffle/pool streams in the *Stream Habitat Assessment Project Procedure (SHAPP, MoDNR 2016c)*. Stream bed and bank morphology were assessed using 10 habitat measures: epifaunal substrate cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, riffle quality, bank stability, bank vegetative protection, and riparian vegetative zone width. Each habitat measure was scored based on a range between zero and 20, where higher values indicated higher quality habitat conditions. The total habitat score equaled the sum of scores for each habitat measure assessed along 10 separate sections of the sample reach. A stream reach was defined as 20 times the average width of the stream. Scores for each habitat measure were determined by either an average or selection of the predominant category. The study stream habitat scores were compared to the BIOREF habitat scores at Sinking Creek in Reynolds County. Habitat scores were compared between the study stream and the reference stream. Study stream habitat scores that were ≥ 75 percent of the BIOREF stream habitat scores indicated these habitats should be able to support biological communities comparable to the reference stream (MoDNR 2016c).

4.2 Macroinvertebrate Collection and Analysis

East Fork Black River was classified as a riffle/pool stream where samples were collected from the following three habitats: flowing water over coarse substrate (**CS**), non-flowing water over depositional substrate (**NF**), and rootmat substrate (**RM**) in accordance with *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP) (MoDNR 2019c)*.

4.3 Macroinvertebrate Laboratory Processing

Habitat samples were subsampled under 10 times magnification, and macroinvertebrate specimens were identified to specific taxonomic levels (MoDNR 2016d) in the laboratory.

Macroinvertebrate Stream Condition Index (**MSCI**) scores of EFBR were calculated based on benthic macroinvertebrate subsamples. MSCI scores were determined based on biological criteria values calculated using BIOREF sample data within the Ozark/Current/Black EDU (MoDNR 2019c). The MSCI is based on four biological metrics: taxonomic richness (**TR**); Ephemeroptera, Plecoptera and Trichoptera Taxonomic Richness (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score ranging between 16 and 20 is considered “fully supporting,” between 10 and 14 is “partially supporting,” and between 4 and 8 is “non-supporting” of the protection of warm-water habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2018f). Data were compared within rather than across seasons for the sampling periods in the fall 2017 and spring 2018.

4.4 Physicochemical Data Collection and Analysis

Water chemistry samples were collected from each of the four sampling stations in accordance with the MoDNR Standard Operating Procedure (**SOP**) *Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2018e). Water parameters were collected as grab samples and included ammonia as nitrogen, total nitrogen, nitrite and nitrate as nitrogen, total phosphorus, chloride, hardness, non-filterable residue, and sulfate. Additional water quality parameters were collected *in situ*, which included temperature (°C) (MoDNR 2018d), specific conductance ($\mu\text{S cm}^{-1}$) (MoDNR 2018a), dissolved oxygen (mg L^{-1}) (MoDNR 2019a), pH (standard units) (MoDNR 2018c), and discharge (cfs) (MoDNR 2017). Turbidity (NTU) (MoDNR 2018b) samples were collected in the field and kept on ice to be measured in the WQMS biology laboratory. All samples were kept on ice and transported to the Chemical Analysis Section (**CAS**) of ESP in Jefferson City, Missouri. Physicochemical values were compared to WQS (MoDNR 2018f); nutrients and turbidity were compared to the 25th percentile of ecoregion XI as designated by the Environmental Protection Agency (**EPA**) (USEPA 2000).

4.5 Quality Assurance/Quality Control (QA/QC)

4.5.1 Field Meters

Field meters necessary for the collection of temperature, turbidity, dissolved oxygen, pH, and discharge were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016a).

4.5.2 Duplicate Sample Collection

Duplicate water physicochemistry and macroinvertebrate samples were collected at station EFBR #1 during the spring 2018 sampling season and were indicated as such in this study as EFBR #1a and EFBR #1b. Duplicates were collected because the goal of the sampling protocols is to assess precision in WQMS methodologies and analyses. To obtain these duplicates, samples were collected at approximately the same time and at the same physical location within a stream in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019b). A Quantitative Similarity Index for Taxa (**QSIT**), which compares the taxonomic presence and abundance between samples (MoDNR 2019c), was calculated for the duplicates. Macroinvertebrate duplicates with a QSIT greater than 70 percent are considered to be comparable (Rabeni et al. 1999, MoDNR 2019c).

4.5.3 Biological Samples

Macroinvertebrates from collected samples were checked for accuracy using methods in the SMSBPP (MoDNR 2019c).

4.5.4 Biological Data Entry

Macroinvertebrate data were entered into the WQMS macroinvertebrate database in accordance with *Quality Control Procedures for Data Processing* (MoDNR2016b).

5.0 Data Results

5.1 Stream Habitat

Habitat parameters at East Fork Black River scored high in comparison to the reference stream. Several parameters, which scored greater than 15 across all stations included epifaunal substrate cover, embeddedness, channel alteration, and bank stability (Table 2). Sediment deposition and vegetative protection scored low among all stations and at the reference stream. Riparian zone width scored especially low at EFBR #6, but the highest scores of riffle quality also occurred here. The highest scores in the velocity/depth regime, sediment deposition, and riparian vegetative zone width occurred at EFBR #3; however, the lowest score in bank stability occurred here too. Overall, all stations, except EFBR #6, were at least 90 percent comparable to the reference habitat (Figure 2).

Table 2. Habitat Assessment of East Fork Black River (ERBR) Stations During the Fall of 2017.

Parameter	Station				Reference
	EFBR #1	EFBR #2	EFBR #3	EFBR #6	
Epifaunal substrate cover	18	16	17	17	15
Embeddedness	20	16	19	18	18
Velocity/depth regime	14	14	17	14	20
Sediment deposition	6	4	11	10	5
Channel flow status	8	14	12	8	8
Channel alteration	20	19	18	16	18
Riffle quality	12	10	11	16	17
Bank stability	18	20	16	20	19
Vegetative protection	0	4	1	2	1
Riparian vegetative zone width	14	14	20	5	20
Total score	130	131	142	126	141
Percent of reference	92.2	92.9	100.7	89.4	100.0

Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. The reference stream was Sinking Creek, Reynolds County, Missouri.

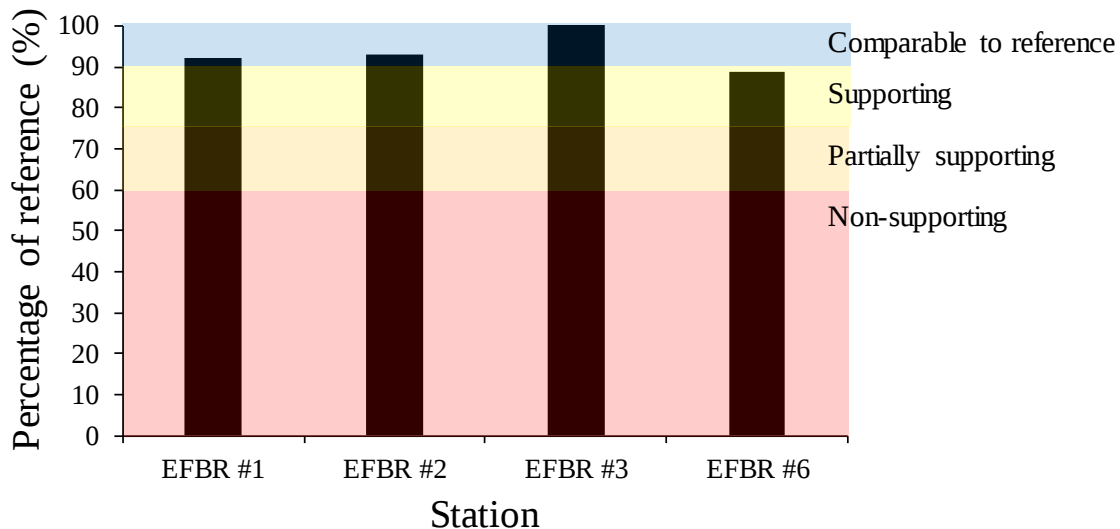


Figure 2. Stream Habitat Assessment Comparison among East Fork Black River (EFBR) Study Stations and the Reference Station at Sinking Creek During the Fall of 2017.

Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.2 Physicochemical Data

Two of the fall physicochemical parameters were markedly different at station EFBR #3 compared to the remaining stations. Dissolved oxygen was lowest at EFBR #3 in the fall season, and turbidity was highest here during both seasons (Tables 3 and 4). Due to human error, dissolved oxygen was not recorded at EFBR #2 in the spring. Turbidity included several values that exceeded EPA recommended criteria for ecoregion XI (EPA 2000). Flow was lowest at EFBR #6 during both seasons, and conductivity was either lowest or highest depending on the season.

Table 3. Fall 2017 East Fork Black River Flow and *In situ* Water Quality Measurements.

Station	Parameter					
	Flow (cfs)	Temp. (°C)	D.O. (mg/L)	Cond. (µS/cm)	pH	Turbidity (NTU)
EFBR #1	6.0	25.4	7.53	184	7.6	0.87
EFBR #2	6.5	27.6	8.56	190	8.2	1.17
EFBR #3	5.9	24.0	6.20	173	7.6	3.13
EFBR #6	3.6	24.9	7.90	27.3	7.8	1.12

Notes: Values in bold indicate an exceedance of recommended P25 EPA criteria for this ecoregion (Turbidity = 1.425 NTU), EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Table 4. Spring 2018 East Fork Black River Flow and *In situ* Water Quality Measurements.

Station	Parameter					
	Flow (cfs)	Temp. (°C)	D.O. (mg/L)	Cond. (µS/cm)	pH	Turbidity (NTU)
EFBR #1a	61.4	8.0	11.32	137	8.5	2.2
EFBR #1b	61.5	8.0	11.32	137	8.4	3.0
EFBR #2	59.1	9.5	-	132	8.6	4.2
EFBR #3	64.7	8.4	11.56	122	8.2	5.0
EFBR #6	27.8	7.5	12.00	152	8.5	<1.0 ¹

Notes: Values in bold indicate an exceedance of recommended P25 EPA criteria for this ecoregion (Turbidity = 1.425 NTU), dash indicates missing data value, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. 1 = not detected at reported value.

Nutrient levels remained at low concentrations among EFBR stations during both sample seasons. In general, nutrients were all higher in downstream stations in comparison to EFBR #6 in JSISP (Tables 5 and 6). Ammonia concentrations varied little, with only a slight increase at EFBR #1 in the fall season. Total phosphorus was in exceedance of EPA nutrient recommended criteria (USEPA 2000) across all stations in the fall and at EFBR #2 and EFBR #3 during the spring season.

Table 5. Fall 2017 East Fork Black River Watershed Nutrient Concentrations.

Station	Parameter (mg/L)			
	NH ₃ -N	NO ₂ +NO ₃ -N	Total Nitrogen	Total Phosphorus
EFBR #1	0.031 ²	0.064	0.16	0.015
EFBR #2	<0.02 ¹	0.066	0.15	0.013
EFBR #3	<0.02 ¹	0.098	0.25	0.018
EFBR #6	<0.02 ¹	0.037	0.088	0.011

Notes: Values in bold indicate an exceedance of recommended P25 EPA criteria for this ecoregion (Total phosphorus = 0.006625 mg/L), EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. 1 = not detected at reported value. 2 = estimated value, detected below PQL.

Table 6. Spring 2018 East Fork Black River Watershed Nutrient Concentrations.

Station	Parameter (mg/L)			
	NH ₃ -N	NO ₂ +NO ₃ -N	Total Nitrogen	Total Phosphorus
EFBR #1a	<0.02 ¹	0.11	0.13	<0.005 ¹
EFBR #1b	<0.02 ¹	0.10	0.15	<0.005 ¹
EFBR #2	<0.02 ¹	0.10	0.14	0.0068
EFBR #3	<0.02 ¹	0.10	0.18	0.014
EFBR #6	<0.02 ¹	0.050	0.052	<0.005 ¹

Notes: Values in bold indicate an exceedance of recommended P25 EPA criteria for this ecoregion (Total phosphorus = 0.006625 mg/L), a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. 1 = not detected at reported value.

Additional physicochemical parameters were highest in JSISP and lower in the remaining downstream stations excluding sulfate (Tables 7 and 8). Chloride, calcium, magnesium, and hardness were all highest at EFBR #6 and at lower levels downstream during both sample seasons. Sulfate levels were greatest at EFBR #2 during both seasons. Total suspended solids (TSS) were below detectable levels except during the spring where EFBR #3 had a TSS of 6.0 mg/L.

Table 7. Fall 2017 East Fork Black River Additional Physicochemical Parameters.

Station	Parameter (mg/L)					Total Suspended
	Chloride	Calcium	Magnesium	Hardness	Sulfate	Solids
EFBR #1	1.32 ²	19.7	11.7	97.4	4.85 ²	<5 ¹
EFBR #2	<1 ¹	20.5	12.4	102	5.22	<5 ¹
EFBR #3	<1 ¹	19.2	12.1	97.8	4.96 ^{2,3}	<5 ¹
EFBR #6	1.49 ²	28.3	16.5	139	4.65 ²	<5 ¹

Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. 1 = not detected at reported value. 2 = estimated value, detected below PQL, 3 = estimated value, QC data outside limits.

Table 8. Spring 2018 East Fork Black River Additional Physicochemical Parameters.

Station	Parameter (mg/L)					Total Suspended
	Chloride	Calcium	Magnesium	Hardness	Sulfate	Solids
EFBR #1a	1.77 ²	13.0	7.88	64.9	7.90	<5 ¹
EFBR #1b	1.80 ²	13.7	8.32	68.5	7.00	<5 ¹
EFBR #2	1.79 ²	13.1	7.96	65.5	9.08	<5 ¹
EFBR #3	1.89 ²	12.8	7.72	63.8	6.37	6.0
EFBR #6	2.06 ²	16.5	9.96	82.2	8.50	<5 ¹

Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park. 1 = not detected at reported value. 2 = estimated value, detected below PQL, 3 = estimated value, QC data outside limits.

5.3 Macroinvertebrate Community Composition

5.3.1 Macroinvertebrate Stream Condition Index

With the exception of EFBR #3, all stations attained fully supporting MSCI scores (Tables 9, 10, 11, and 12). Taxa richness (TR) was highest at EFBR #6 and lowest at EFBR #3 during both sample seasons (Figures 3 and 4). The EPTT metric value was lowest at station EFBR #3. The SDI was highest at EFBR #2 during both seasons. The BI varied and was lowest at stations EFBR #1 and EFBR #6 during the fall and at EFBR #6 during the spring. All metric values for TR, EPTT, and SDI were lowest at station EFBR #3, excluding the SDI in the spring (Figures 3 and 4). Further, the BI was highest at EFBR #3.

Table 9. Fall 2017 Biological Criteria for Warm Water Reference Streams in the Ozark/Black/Current EDU.

Metric	Score = 5	Score = 3	Score = 1
TR	>85	85-43	<43
EPTT	>25	25-13	<13
BI	<5.2	5.2-7.6	>7.6
SDI	>3.28	3.28-1.65	<1.64

Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon's Diversity Index.

Table 10. Spring 2018 Biological Criteria for Warm Water Reference Streams in the Ozark/Black/Current EDU.

Metric	Score = 5	Score = 3	Score = 1
TR	>93	93-47	<47
EPTT	>31	31-15	<15
BI	<5.4	5.4-7.7	>7.7
SDI	>3.37	3.37-1.69	<1.69

Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon's Diversity Index.

Table 11. Fall 2017 Metric Values and Scores for East Fork Black River Stations.

Station	TR	EPTT	BI	SDI	MSCI	Support
EFBR #1	75 (3)	31 (5)	5.3 (3)	3.52 (5)	16	Full
EFBR #2	86 (5)	33 (5)	5.8 (3)	3.54 (5)	18	Full
EFBR #3	61 (3)	25 (3)	5.6 (3)	2.92 (3)	12	Partial
EFBR #6	90 (5)	30 (5)	5.3 (3)	3.52 (5)	18	Full

Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon Diversity Index, values in () indicate metric scores. EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Table 12. Spring 2018 Metric Values and Scores for East Fork Black River Stations.

Station	TR	EPTT	BI	SDI	MSCI	Support
EFBR #1a	90 (3)	34 (5)	5.2 (5)	3.38 (5)	18	Full
EFBR #1b	92 (3)	36 (5)	5.2 (5)	3.32 (3)	16	Full
EFBR #2	99 (5)	33 (5)	5.6 (3)	3.72 (5)	18	Full
EFBR #3	88 (3)	25 (3)	6.1 (3)	3.35 (3)	12	Partial
EFBR #6	103 (5)	34 (5)	5.0 (5)	3.56 (5)	20	Full

Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon Diversity Index, values in () indicate metric scores, a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

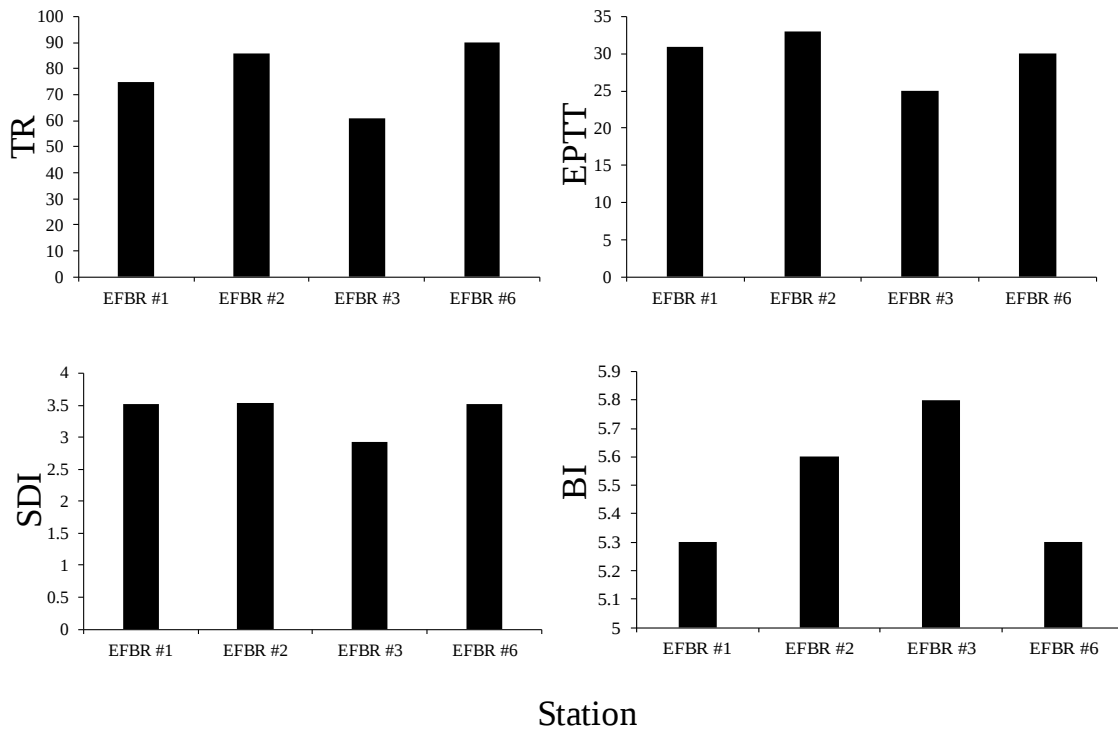


Figure 3. Fall 2017 Macroinvertebrate Stream Condition Index (MSCI) Individual Metrics at East Fork Black River. Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon's Diversity Index, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

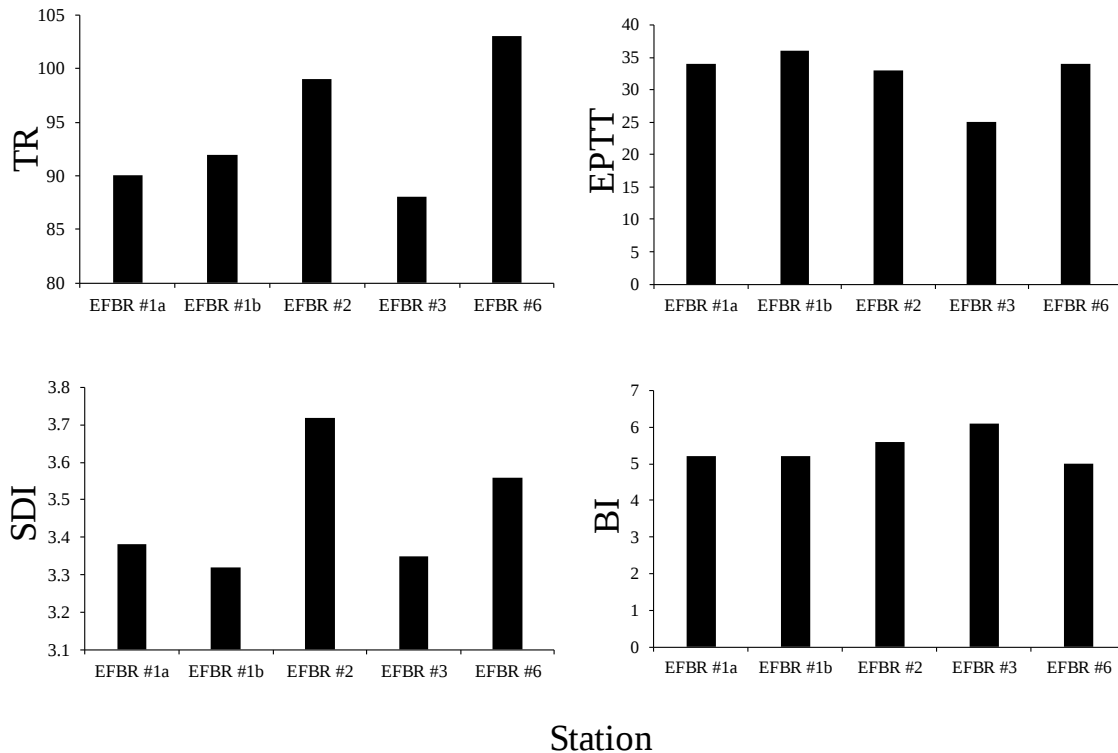


Figure 4. Spring 2018 Macroinvertebrate Stream Condition Index (MSCI) Individual Metrics at East Fork Black River. Notes: TR = Taxa Richness, EPTT = Ephemeroptera, Trichoptera, Plecoptera Taxonomic Richness, BI = Biotic Index, SDI = Shannon's Diversity Index, a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.3.2 Macroinvertebrate Sensitivity

Pollution-sensitive macroinvertebrate orders were abundant at various stations, dependent upon the season. Percent Ephemeroptera was highest at station EFBR #3 during both seasons (Tables 13 and 14). The percent Trichoptera was highest at EFBR #3 during the fall, and this percent was highest at EFBR #2 during the spring. Plecoptera percentages differed from the other two sensitive orders. Percent Plecoptera was highest at EFBR #2 during the fall and highest at EFBR #6 during the spring.

Table 13. Fall 2017 East Fork Black River Sensitive Orders.

Order (%)	Station			
	EFBR #1	EFBR #2	EFBR #3	EFBR #6
Ephemeroptera	27.1	24.4	53.8	30.3
Plecoptera	1.3	2.9	0.9	1.3
Trichoptera	13.0	8.8	14.6	7.4

Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Table 14. Spring 2018 East Fork Black River Sensitive Orders.

Order (%)	Station				
	EFBR #1a	EFBR #1b	EFBR #2	EFBR #3	EFBR #6
Ephemeroptera	24.6	19.6	21.6	25.7	22.7
Plecoptera	4.1	3.9	3.1	1.3	5.0
Trichoptera	9.1	8.2	9.2	7.2	8.5

Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

The most common fall EPT taxa included both tolerant and intolerant taxa. For example, *Caenis latipennis* (BI = 7.6) was common at all stations except EFBR #2, and *Stenonema femoratum* (BI = 7.5) was common at stations EFBR #3 and EFBR #6 (Table 15). *Tricorythodes* has a mid-range tolerance level (BI = 5.4) and was common at EFBR #3. Other intolerant Ephemeroptera included *Maccaffertium mediopunctatum* (BI = 1.7), *Isonychia bicolor* (BI = 2), and *M. pulchellum* (BI = 3), which were common at one or several of the stations (EFBR #2, EFBR #3, and EFBR #6). The common Trichoptera were *Cheumatopsyche* (BI = 6.6), *Chimarra* (BI = 2.8), and *Helicopsyche* (BI = 0). *Neoperla* was the most common Plecoptera taxon present and was present in high abundance at station EFBR #2.

Common spring EPT taxa included an assemblage similar to fall taxa. *C. latipennis* and *S. femoratum* were commonly collected again, and *Tricorythodes* was common only at EFBR #3 (Table 16). *Cheumatopsyche* was abundant again, as in the fall season, and was among the dominant taxa among all stations except EFBR #1. Similar to the fall season, *Neoperla* was the most common stonefly taxon at station EFBR #2.

Table 15. Fall 2017 East Fork Black River Dominant Taxa.

Taxa	BI	Station			
		EFBR #1	EFBR #2	EFBR #3	EFBR #6
<i>Stenelmis</i>	5.4	12.3	13.3	5.4	17.9
<i>Caenis latipennis</i>	7.6	7.1	-	12.8	3.9
<i>Argia</i>	8.7	6.4	4.1	-	-
<i>Tanytarsus</i>	6.7	6.3	5.6	-	2.8
<i>Rheotanytarsus</i>	6.4	5.9	-	-	-
<i>Polypedilum flavum</i>	5.3	5.2	-	4.3	-
<i>Maccaffertium mediopunctatum</i>	1.7	4.8	2.9	-	2.9
<i>Helicopsyche</i>	0	3.6	-	-	3.2
<i>Chimarra</i>	2.8	3.3	-	7.2	-
<i>Acarina</i>	5.7	3.0	10.0	-	-
<i>Tribelos</i>	6.6	-	-	-	9.9
<i>Isonychia bicolor</i>	2	-	-	3.2	5.2
<i>Maccaffertium pulchellum</i>	3	-	3.1	-	5.2
<i>Hyalella azteca</i>	7.9	-	7.3	-	4.5
<i>Stenonema femoratum</i>	7.5	-	-	7.6	4.0
<i>Caenis anceps</i>	7.6	-	3.2	-	-
<i>Cheumatopsyche</i>	6.6	-	2.7	5.4	-
<i>Neoperla</i>	1.6	-	2.7	-	-
<i>Tricorythodes</i>	5.4	-	-	24.2	-
Planariidae	7.5	-	-	4.3	-
<i>Cricotopus/Orthocladius</i>	6.5	-	-	2.0	-

Notes: BI = biotic index, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Table 16. Spring 2018 East Fork Black River Dominant Taxa.

Taxa	BI	Station				
		EFBR #1a	EFBR #1b	EFBR #2	EFBR #3	EFBR #6
<i>Stenelmis</i>	5.4	22.8	21.7	11.1	15.9	8.1
<i>Cricotopus/Orthocladius</i>	6.5	9.9	14.4	8.6	8.1	10.7
<i>Isonychia bicolor</i>	2	6.5	7.8	5.5	4.1	2.9
<i>Caenis latipennis</i>	7.6	3.9	2.2	-	8.8	6.0
<i>Oxyethira</i>	3	3.6	2.9	-	-	-
<i>Tanytarsus</i>	6.7	3.2	3.5	5.2	3.8	-
<i>Maccaffertium mediopunctatum</i>	1.7	3.2	2.0	-	-	-
<i>Caenis anceps</i>	7.6	3.2	-	-	-	-
<i>Rheotanytarsus</i>	6.4	2.5	3.8	-	-	-
<i>Stenonema femoratum</i>	7.5	2.3	1.8	-	2.9	-
<i>Thienemannimyia</i> grp.	6	-	2.7	-	-	4.2
<i>Hyalella azteca</i>	7.9	-	-	7.8	3.7	-
<i>Cheumatopsyche</i>	6.6	-	-	3.9	2.8	4.2
Acarina	5.7	-	-	3.4	-	-
<i>Maccaffertium pulchellum</i>	3	-	-	2.9	-	6.0
<i>Stempellinella</i>	5.3	-	-	2.9	-	-
<i>Neoperla</i>	1.6	-	-	2.5	-	-
<i>Tricorythodes</i>	5.4	-	-	-	8.0	-
Planariidae	7.5	-	-	-	6.2	-
<i>Polypedilum aviceps</i>	3.7	-	-	-	-	9.5
<i>Prosimulium</i>	2.6	-	-	-	-	8.6
Heptageniidae	4	-	-	-	-	2.6

Notes: BI = biotic index, a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Stations varied in overall macroinvertebrate community tolerance. During both seasons, station EFBR #3 had the lowest percentage of taxa with a BI < 1 (Figure 5). EFBR #3 also had the highest community percentage with a BI = 7 – 10. The highest community percentage with a BI ≤ 4.9 was station EFBR #6.

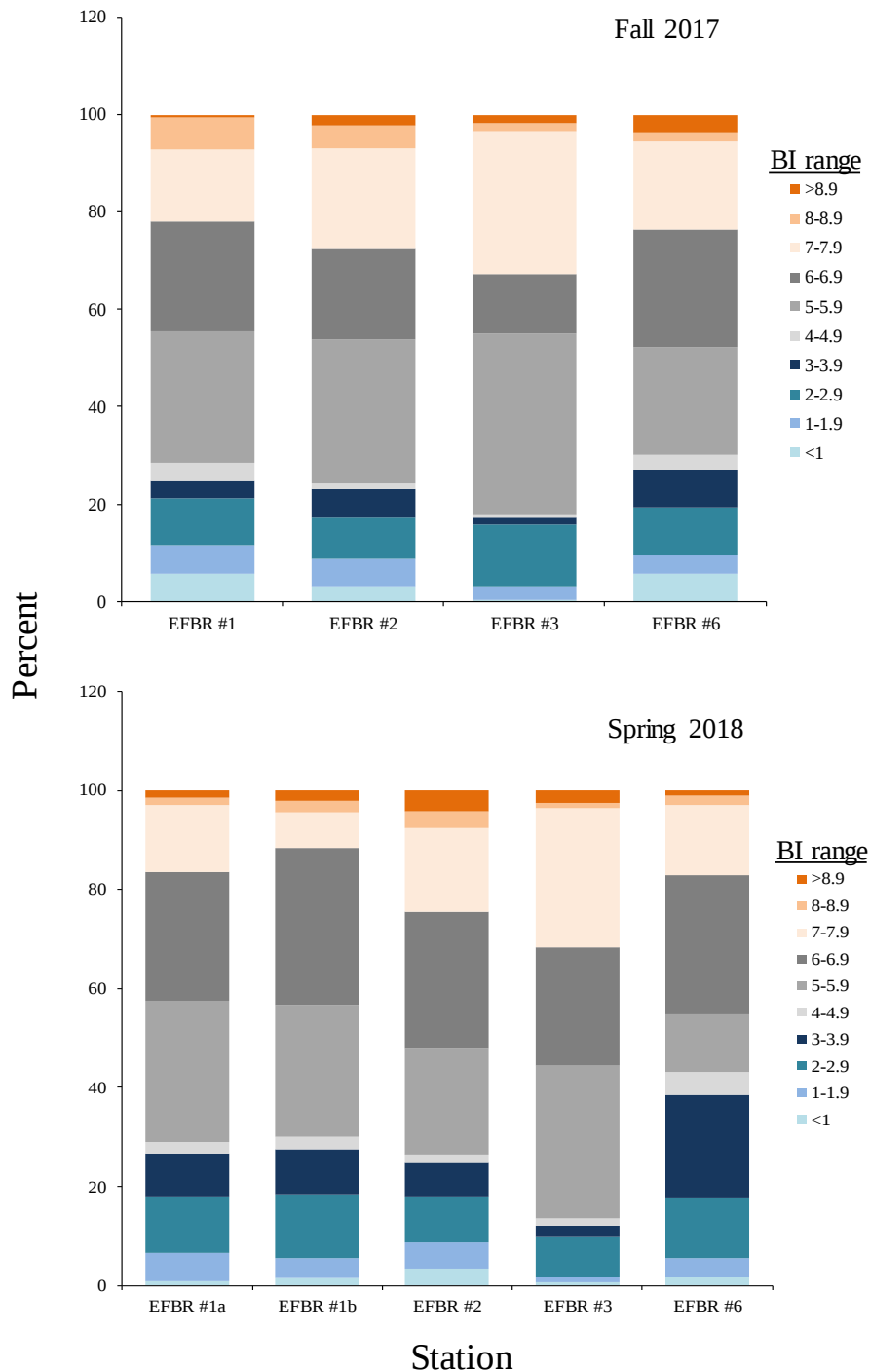


Figure 5. Biotic Index (BI) Ranges at Stations of East Fork Black River. Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.3.3 Macroinvertebrate Community Comparisons

Fall macroinvertebrate community composition varied across stations, especially between stations EFBR #6 and EFBR #3 (Figure 6). The abundance of Amphipoda was higher at stations EFBR #2 and EFBR #6 in comparison to remaining stations. Station EFBR #3 differed from other stations in having a dominance of Ephemeroptera but fewer Odonata, Amphipoda, Coleoptera, and Diptera. Despite a dominance by Ephemeroptera at EFBR #3, the quantity of Trichoptera also increased in addition to Tricladida (planarians). Plecoptera made up at least 1 percent of all stations except at EFBR #3.

In the spring, the EFBR #6 macroinvertebrate community was very different from the stations downstream of the Lower Taum Sauk Reservoir. Station EFBR #6 was dominated by Diptera, had lower abundances of Coleoptera, and higher abundances of Plecoptera (Figure 7). Station EFBR #6 also had a lower quantity of Coleoptera and a higher quantity of Plecoptera when compared to remaining stations. Tricladida were highest at station EFBR #3, as in the fall season, whereas Amphipoda contributed to more of the EFBR #2 and EFBR #3 station communities.

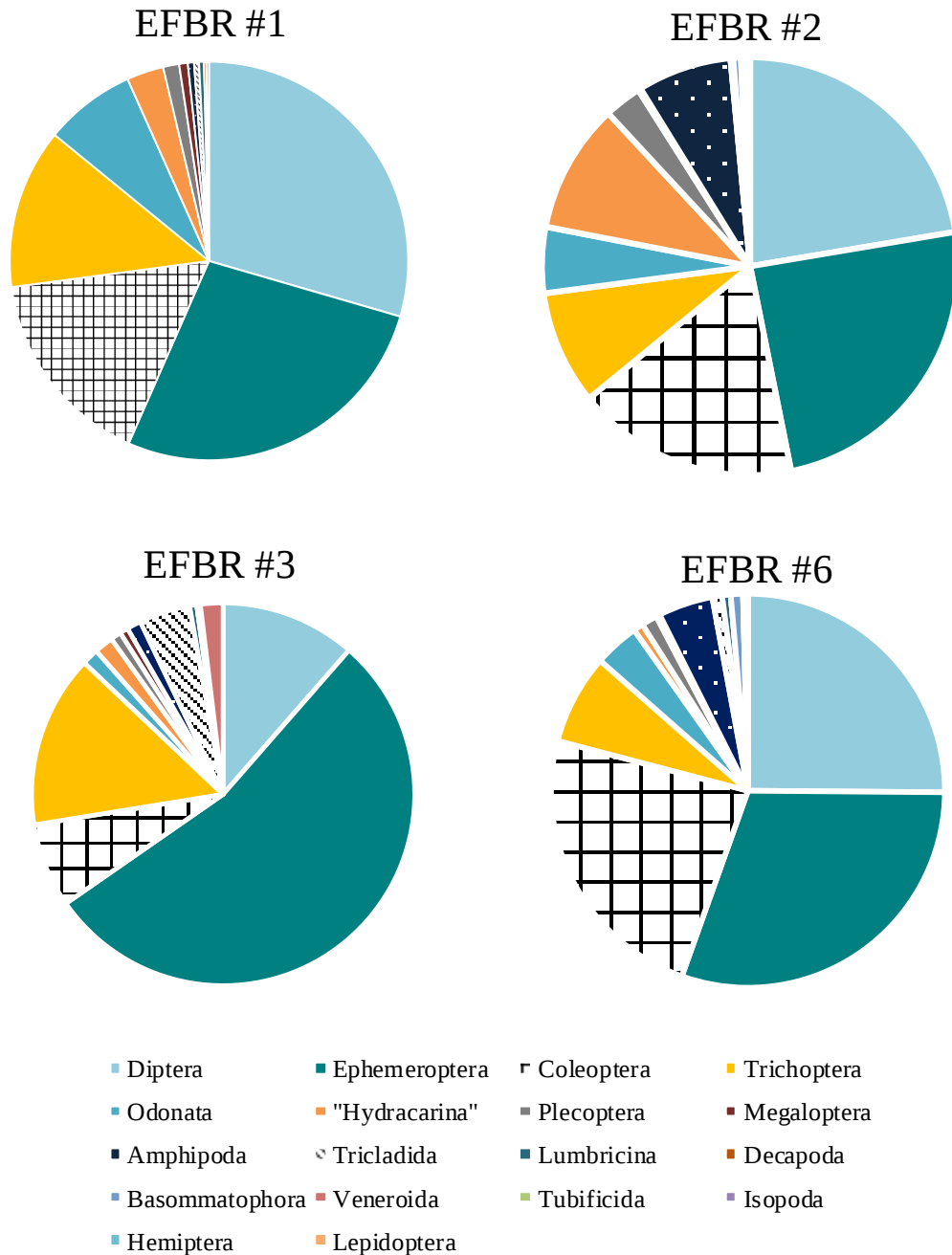


Figure 6. Fall 2017 Percent Macroinvertebrate Composition among Stations on East Fork Black River. Notes: EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

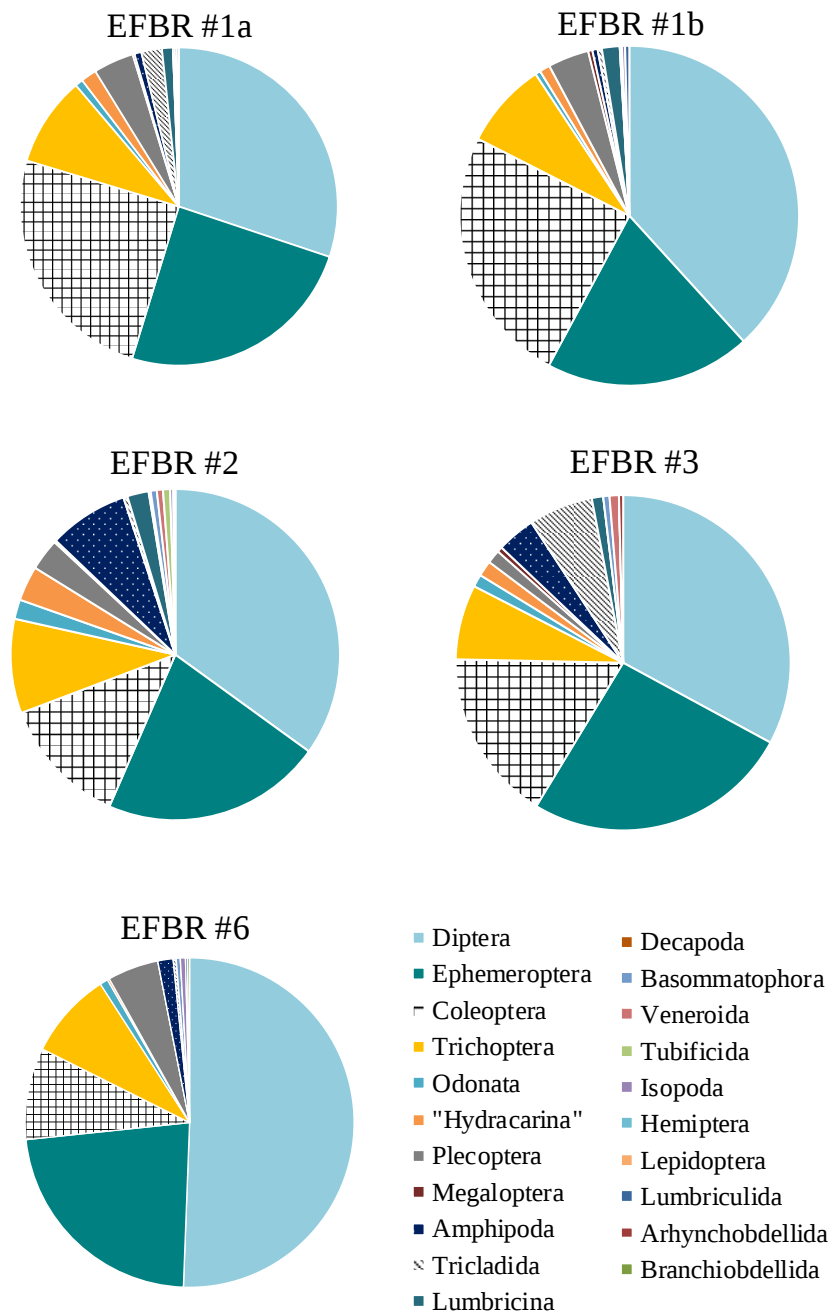


Figure 7. Spring 2018 Percent Macroinvertebrate Composition among Stations on East Fork Black River. Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-In State Park.

5.3.4 Macroinvertebrate Functional Feeding Groups

The functional feeding group (FFG) metric had the greatest within-season compositional shift at station EFBR #3 in comparison to remaining stations. During the fall and spring seasons, station EFBR #3 had more gatherer-collectors than remaining stations. During the fall, EFBR #3 had fewer predators and scrapers than other stations (Figure 8).

Filterer-collectors were highest at the most downstream station (EFBR #1), and scrapers were highest at station EFBR #6. During the spring season, shredders were in greatest abundance at the most upstream station, EFBR #6.

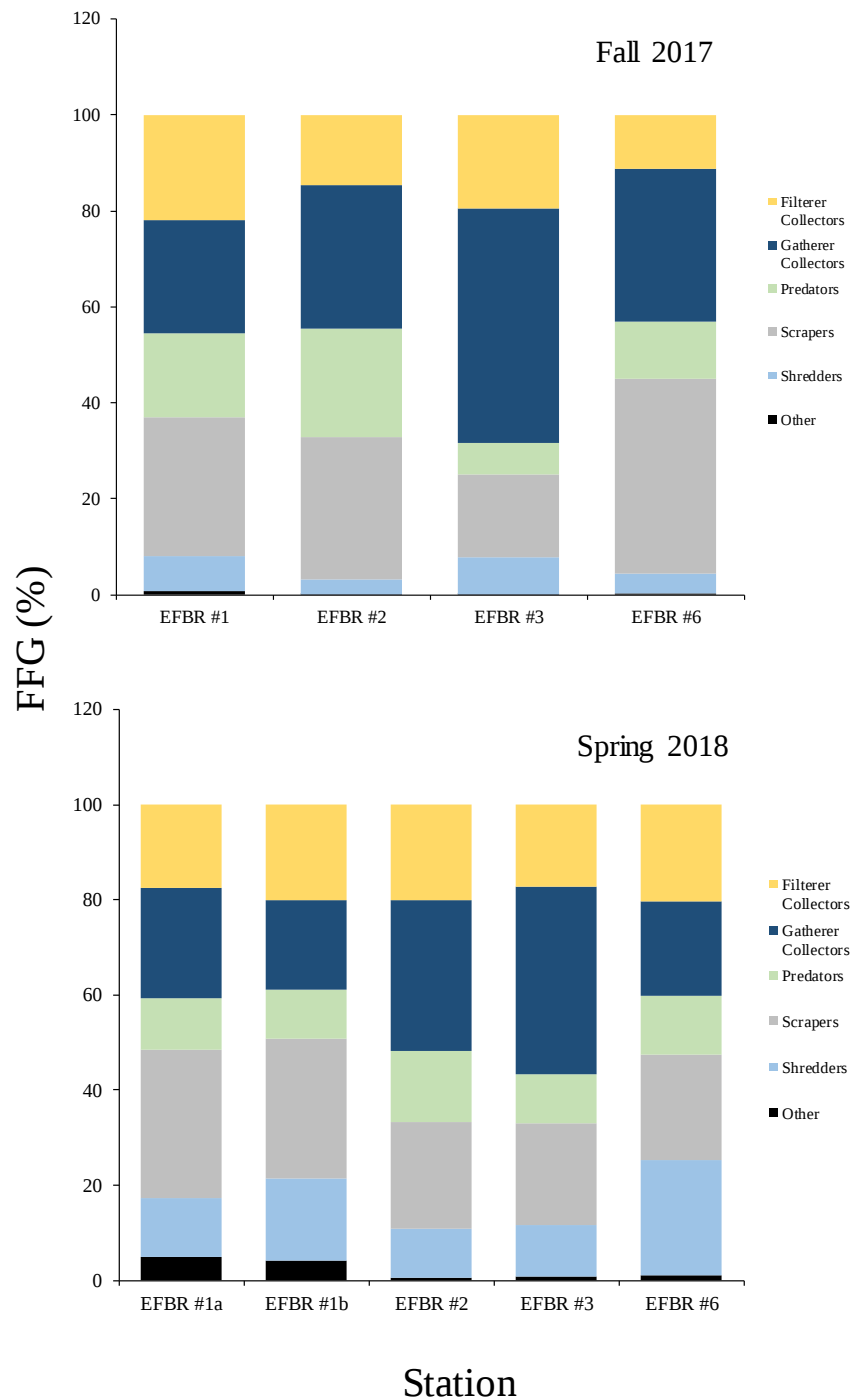


Figure 8. Functional Feeding Groups among Stations on East Fork Black River. Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.3.5 Macroinvertebrate Uniqueness

The macroinvertebrate community across stations of East Fork Black River was also compared using unique taxa. During the fall, stations with the most unique (station specific) taxa were EFBR #2 and EFBR #6, and station EFBR #3 was most similar to neighboring stations (Figure 9). During the spring, station EFBR #1 was the most taxonomically unique, and EFBR #2 and EFBR #3 stations had the most taxa in common with remaining stations.

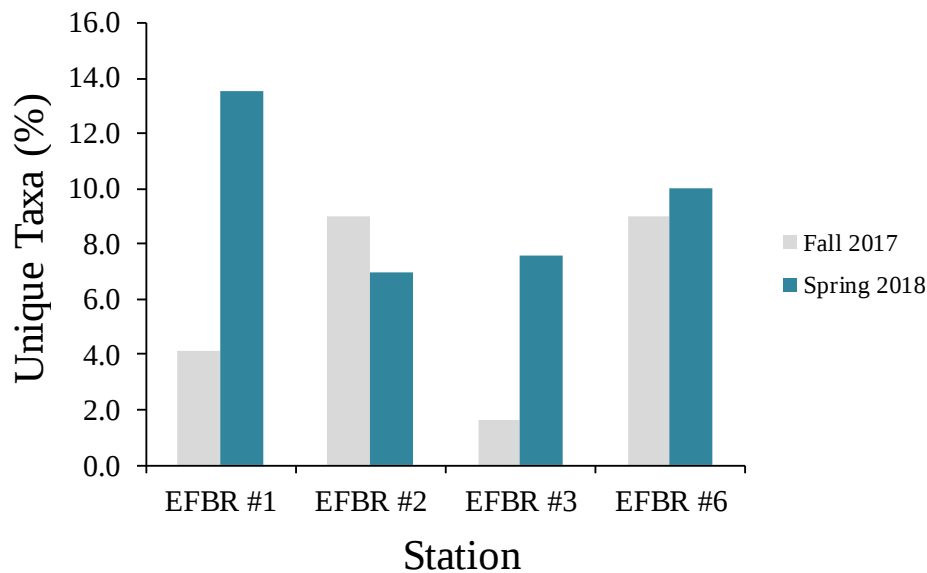
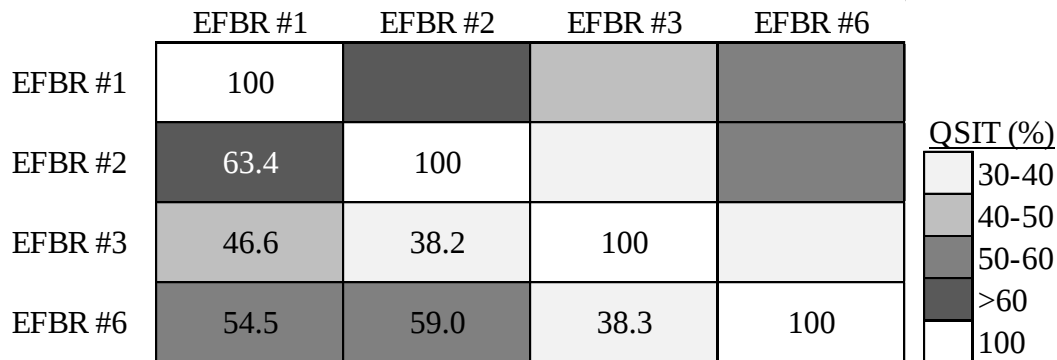


Figure 9. Percentage of Unique Taxa from Stations at East Fork Black River. Notes: duplicates a and b collected in the spring 2018 were combined, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

Unique macroinvertebrate communities among EFBR stations can be compared with the QSIT. The QSIT accounts for not only the types of taxa present but also the taxa quantities to calculate a percentage of community similarity. During the fall season, the EFBR #3 macroinvertebrate community was the most dissimilar to remaining stations (Figure 10). Highest community similarity occurred across stations EFBR #1 and EFBR #2. Similarly, in the spring EFBR #1 and EFBR #2 had greatest macroinvertebrate community similarity, and the most dissimilarity occurred between EFBR #6 and remaining downstream stations.

Fall 2017



Spring 2018

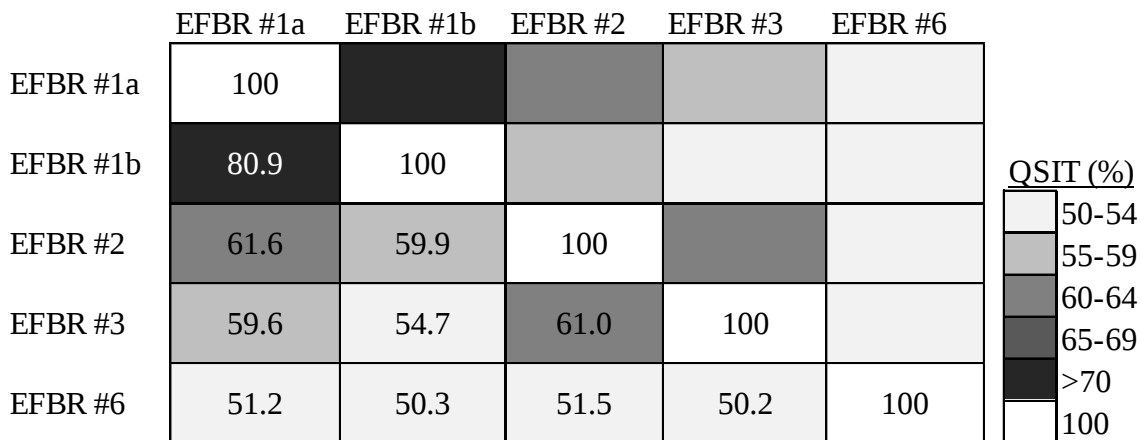


Figure 10. Similarity among Stations of East Fork Black River Measured with the Quantitative Similarity Index for Taxa (QSIT). Notes: a and b denote duplicates, EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.3.6 History of Macroinvertebrate Scores

Since 2005, MSCI scores have increased or remained constant among EFBR stations. EFBR #3 has failed to attain a fully supporting MSCI for either season, except during the fall 2007 (Figure 11). Stations EFBR #1 and EFBR #2 have continually maintained a fully-supporting classification, except during spring 2006 at EFBR #1.

Since the Upper Taum Sauk Reservoir failure in December 2005, the greatest change in MSCI scores occurred at station EFBR #6 where scores have increased. EFBR #6 was sampled in spring 2006, approximately three months after the upper reservoir failure. At that time, the MSCI score at EFBR #6 was 8. In spring 2018, however, it attained a score of 20, changing from a non-supporting to a fully-supporting classification with the highest possible MSCI score.

Before the reservoir failure, EFBR #6 occasionally attained partially supporting MSCI scores. Of five samples collected between 1999 and 2005, two samples (spring 2000 and fall 2005) had partially supporting MSCI scores of 14. Following the reservoir failure, extensive efforts were undertaken to remove debris and fine sediment from the river. After this work was completed, the EFBR began flowing in its present channel in April 2007. Partially supporting MSCI scores in fall 2007 and spring 2008 may have been a result of ongoing macroinvertebrate recolonization occurring in the reach. Of 10 samples collected between fall 2008 and spring 2016, two (spring 2011 and fall 2012) had partially supporting scores; the remaining samples were fully supporting.

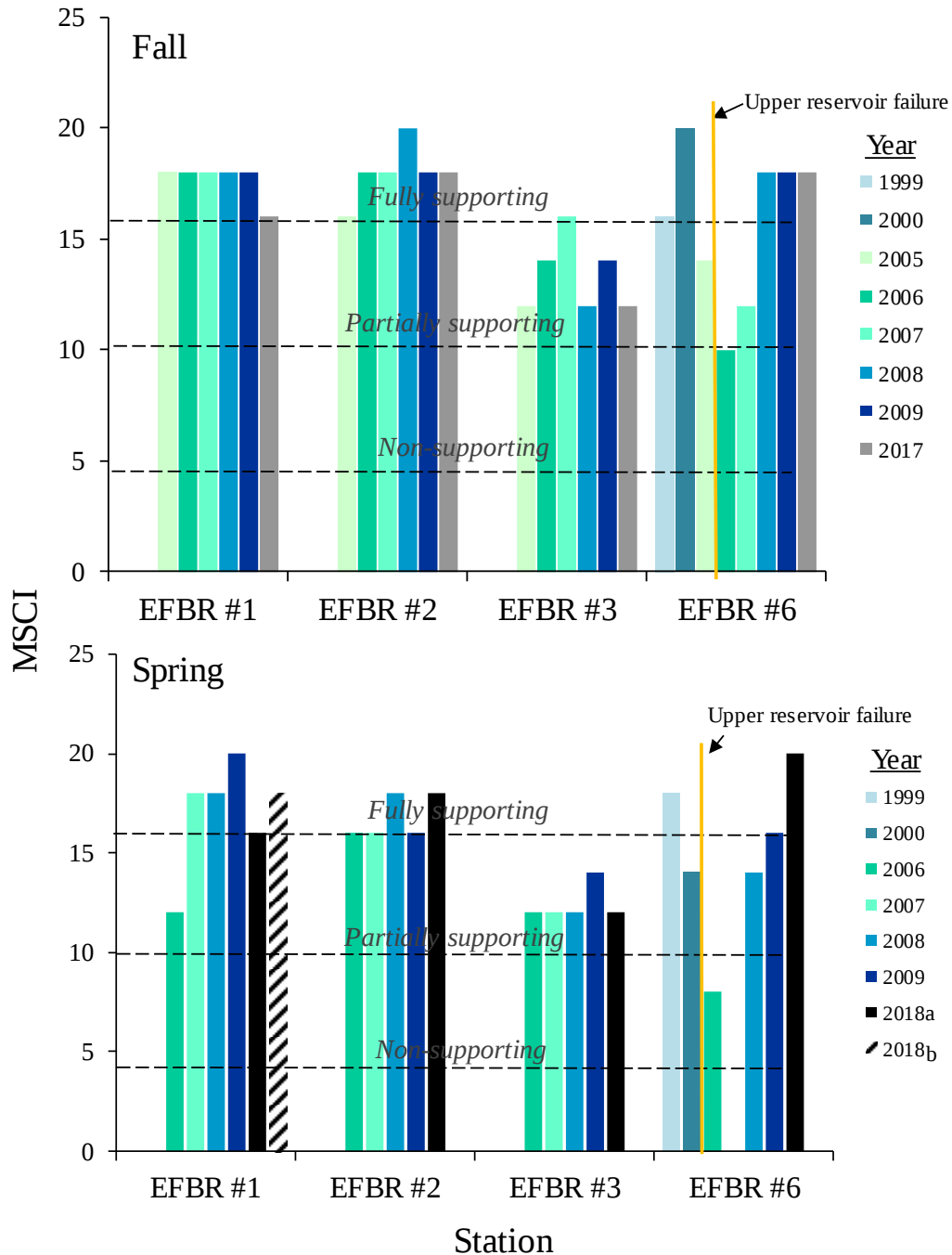


Figure 11. East Fork Black River Missouri Stream Condition Index Overall Score History. Notes: a and b denote duplicates collected during 2018 at station EFBR #1. During the years 1999 and 2000, samples were only collected from EFBR#6. EFBR #1 = station upstream of Highway 21 bridge at Lesterville, EFBR #2 = station in the vicinity of Wicks Cave near Lesterville, EFBR #3 = station downstream of the Lower Taum Sauk Reservoir Dam, EFBR #6 = station was a restored river reach in Johnson's Shut-Ins State Park.

5.4 Quantitative Similarity Index for Taxa

The QSIT value for macroinvertebrate duplicates (EFBR #1a and EFBR #1b) collected at station EFBR #1 during the spring season was 80.0 percent, indicating samples were comparable.

6.0 Discussion

6.1 Stream Habitat

Stream habitat is a critical filter in determining which aquatic species can survive, colonize, and reproduce (Poff 1997). The large-scale variables of channel alteration and bank stability scored well among all EFBR stations while vegetative protection scored poorly among all stations. Further, riparian vegetative zone width scored the highest at EFBR #3. These habitat variables affect characteristics such as water filtration, water temperature, allochthonous input, and nutrient levels. Three of the macroinvertebrate metrics were lowest at EFBR #3. Because EFBR #3 had high bank stability and riparian vegetative zone width scores, the low biological metric scores calculated here indicated a variable affecting the macroinvertebrate community exists that was not captured by the habitat assessment. The macroinvertebrate community was less diverse and stable at EFBR #3 due either to an unmeasured habitat variable or environmental stressor.

In contrast to the low metrics calculated at EFBR #3, no single EFBR station held the majority of the highest macroinvertebrate metrics. Station EFBR #6 had the highest TR and the lowest BI (the BI was the same at EFBR #1), and EFBR #2 had the highest EPTT and SDI. Half the metrics scored highest at the most upstream station, and half the metrics scored highest at the station farthest downstream from the lower reservoir, which may indicate an environmental stressor exists near EFBR #3. It is possible that the altered flow regime from the Lower Taum Sauk Reservoir Dam may be affecting macroinvertebrate communities downstream, with partial recovery occurring at EFBR #2. Habitat scores alone do not account for these metric differences as all habitats across stations scored fairly well. Station EFBR #3 had low embeddedness, heterogeneous velocity and depth regimes, excellent riparian vegetative zone widths, and low channel alteration.

6.2 Physicochemical Analysis

Site-specific water quality trends related spatially to EFBR #3 and were more apparent than seasonal or longitudinal trends. Among these station-specific trends were dissolved oxygen, temperature, and flow, which are all inter-related. The lower reservoir dam was located upstream of station EFBR #3, and during the fall season, *in situ* measures of dissolved oxygen and water temperature were lowest here among stations sampled. Reservoirs with low-release mechanisms typically result in lower dissolved oxygen, lower pH, and cooler temperatures (Brittain and Saltveit 1989). However, the lower Taum Sauk Reservoir dam uses a stop log intake mechanism to allow for water release from variable depths. Despite this structure, dissolved oxygen, captured by a USGS gage (#07061290), fell below 5.0 mg/L at station EFBR #3 during July 8-23, 2018, (USGS

2019) corresponding to a period of extremely low discharge at this station (Figure 12). Another important parameter for aquatic biota is water temperature. Temperature regime determines macroinvertebrate community member development times, diapause, and emergence (Merritt et al. 2008). Because dams can alter the temperature regime downstream, they also can drastically alter the biotic communities that exist downstream (Rader et al. 2008). However, temperature at EFBR #3 was not drastically different from upstream temperatures at EFBR #6 (based on *in situ* measurements). Temperatures at EFBR #3 were only 0.9°C cooler or warmer than the most upstream station during the period samples were collected in this study.

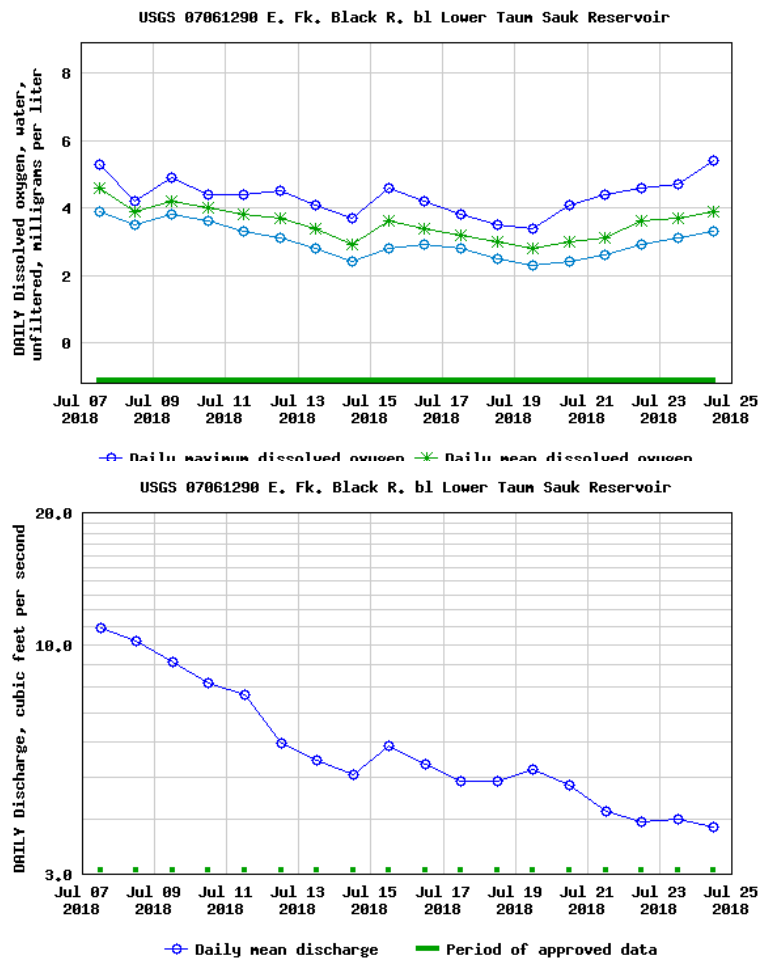


Figure 12. East Fork Black River Dissolved Oxygen and Discharge Data from a USGS Stream Gage Located Below the Lower Taum Sauk Reservoir During a Period of July 2018.

Notes: This gage corresponds to station EFBR #3.

Nutrient concentrations also peaked at EFBR #3 during the fall and spring sample periods. Similar results in other studies have been found downstream of reservoirs especially for nitrite, nitrate, and ammonium (Ellis and Jones 2013, Camargo et al. 2004). Studies on a pumped-storage hydropower plant revealed decreased CPOM/FPOM (coarse and fine particulate organic matter, respectively) and an increase in periphyton biomass downstream of the dam (Kokavec et al. 2017), and these variables further support high nutrient concentrations. Similar trends also existed in previous years at EFBR #3. Total nitrogen concentrations were highest at EFBR #3 in the spring 2009, fall 2008, and fall 2006 time periods (Michaelson 2010, 2009, 2007) when compared to remaining sample stations.

6.3 Biological Assessment

Bioassessment metrics and MSCI scores followed station-specific trends and had a slight seasonal trend. Station EFBR #3 had the lowest metric values in TR, EPTT, and SDI and the highest values in BI during both seasons except for the SDI during the spring 2018. Decreased diversity was previously documented from sites downstream of deep-release dams on the Colorado River (Rader and Ward 1988). Reduced taxonomic richness and diversity also have been found downstream of hydroelectric impoundments globally (Kokavec et al. 2017, Ren et al. 2014, Ellis and Jones 2013, Rader and Ward 1988). These data suggest invertebrate communities downstream of dams typically do poorly. The Biotic Index was highest at EFBR #3, indicating tolerant organisms were abundant there, which follows expectations from another study by Bednarek and Hart (2005). These metric results all align with the more extreme physicochemistry previously discussed concerning dissolved oxygen, temperature, and flow. Further, all MSCI scores were classified as partially supporting at EFBR #3. A slight seasonal trend existed where spring MSCI scores were generally higher than fall MSCI scores.

6.4 Macroinvertebrate Community Composition

The metrics of TR and EPTT were lowest at station EFBR #3 during sampling seasons. Station EFBR #3 is below the lower Taum Sauk Reservoir, and yet it had some of the highest percentages of Ephemeroptera and Trichoptera. The family Heptageniidae within the Ephemeroptera are typically absent from regulated rivers (Rader and Ward 1988), yet this family was present across all sampling stations and included at least five species at a single station. Trichoptera and Plecoptera were more sparsely represented across all sampling stations. Trichoptera include a large proportion of the shredder functional feeding group. Food resources for shredders include CPOM, which tends to decrease downstream of dams because organic matter is trapped upstream (Kokavec et al. 2017, Ellis and Jones 2013). Therefore, shredders have previously been shown to decrease in samples downstream of reservoirs (Goretti et al. 2006, Rader and Ward 1988), and as expected in previous studies, this FFG was lowest at EFBR #3 during the fall season. These data indicate that CPOM may be low at EFBR #3 and may contribute to the macroinvertebrate community changes documented. Plecoptera are among the most sensitive aquatic orders (Merritt et al. 2008, Poulton and Stewart 1991, Baumann 1979),

typically because of temperature and flow sensitivities, and this order was consistently lowest at station EFBR #3, further indicating a more impaired aquatic community exists at this station.

Fall community composition evenness was especially low at station EFBR #3, where Ephemeroptera dominated and Tricladida made up a larger percentage of the samples than in remaining stations. A longitudinal study on the dammed Colorado River resulted in the site directly downstream of the dam having lower abundances of Coleoptera and Plecoptera (Rader et al. 2008), and these two orders were similarly reduced at station EFBR #3. Flow has also been listed among the most important variables to affect aquatic communities, especially Plecoptera (Doisy and Rabeni 2001), and flow did drastically decrease downstream of EFBR #3, especially during the summer as previously discussed. However, low flow also affected the upstream station, where flow (as measured by USGS gages) at EFBR #6 and EFBR #3 was comparable.

The Biotic Index for EFBR stations indicated that all stations were fairly equal in macroinvertebrate tolerance levels except at station EFBR #3 during both seasons. Most taxa across stations fell between the biotic index values of four and seven. However, EFBR #3 had the highest percentage of taxa with a BI > 7 and the lowest percentage of taxa with a BI < 4 in comparison to remaining stations. The driving variable behind this is unlikely to be habitat related as the habitat assessment score at EFBR #3 was actually the highest among stations. Instead, variables of concern may be in water quality where total phosphorus was high according to water quality thresholds by the EPA (USEPA 2000), and where total nitrogen peaked. Higher phosphorus downstream of dams is common (Benítez-Mora and Camargo 2014), and this may be a driver behind higher BI metric values at EFBR #3. Further, dams alter the flow and thermal regimes of streams (Guareschi et al. 2012), which often leads to only the most commonly occurring and tolerant taxa surviving in stream sections downstream of dams (Goretti et al. 2006).

Macroinvertebrate community composition, according to coarser taxonomic groups, was fairly uniform. The diverse order Diptera made up a large portion of all EFBR station communities during both seasons with exceptional abundance during the spring 2018 at EFBR #6. This occurrence was similar to the abundance found during the spring 2009 due to Chironomidae (Michaelson 2009). Nearly 70 percent of the macroinvertebrate community at EFBR #3 was made of Chironomidae in 2009, and this abundance was considerably lower during the spring 2018 at 30.9 percent. During the fall 2017, EFBR #3 macroinvertebrate community composition differed the most from remaining stations, having much higher Ephemeroptera and much lower Coleoptera abundance. The dominant taxon at EFBR #3 was the mayfly *Tricorythodes* with a BI = 7.4, likely contributing to the higher proportion of Ephemeroptera. The mayflies *Caenis latipennis* and *Stenonema femoratum* were also extremely common at EFBR #3, and both these species have higher BI values and are known to be tolerant of degraded environmental conditions (Pond 2010).

Station EFBR #3 had lower unique macroinvertebrate taxa and lower community similarity to remaining stations, indicating a low level of specialization in the macroinvertebrate community. Healthy macroinvertebrate communities usually include sensitive, rare, or endemic taxa in comparison to degraded and impaired stream communities (Smith and Lamp 2008). Further, taxonomic communities with a high degree of similarity are exposed to similar environmental stressors (Magurran 1988). Because EFBR #3 had a lower number of unique taxa, the taxa collected are likely common and fairly tolerant to a wide range of environmental conditions. Both EFBR #3 and EFBR #6 had lower macroinvertebrate community similarities to remaining stations, indicating these communities experience different environments from the rest of the EFBR stations. Station EFBR #6 had better substrate heterogeneity, especially in the riffles, and a more constant flow regime based on experience during sampling. Epifaunal substrate cover scored well across all stations on the habitat assessment, but this was based largely on the presence of many cobble-sized substrates. Visually, EFBR #6 had a wider range of substrate sizes, including gravel, sand, and silt-sized substrate. Dams trap sediments upstream and scour finer substrates downstream (Allan and Castillo 2007), resulting in less substrate heterogeneity and, therefore, less habitat diversity for benthic organisms. Station EFBR #3 macroinvertebrate communities experience an altered flow regime due to the dam and the presence of deeper pool habitats. The flow regime at EFBR #3 may create an environment with a frequent disturbance regime that cannot support a healthy community (Lake 2000) as documented by the low TR calculated in the fall and spring.

6.5 MSCI Historical Data Trends

Historically, station EFBR #3 consistently has had lower MSCI scores than other stations in the survey reach. An EFBR #3 sample collected during the fall of 2005, before the upper reservoir failure, had a partially supporting MSCI score, indicating the macroinvertebrate community here has not necessarily degraded during the time that the MoDNR Aquatic Bioassessment Unit has been sampling this station. Station EFBR #3 has consistently had partially supporting MSCI scores, but this station did obtain a fully supporting classification once during the fall 2007, which indicates the community here does have the ability to attain this classification. Greater flow was stated as a possible cause behind the higher MSCI scores during this season (flow = 50.3 cfs) (Michaelson 2007). Since the fall 2007 *in situ* measures of flow have not been nearly as high as in fall 2007 except during the fall 2009 (65 cfs) when the MSCI did not attain a fully supporting classification.

Station EFBR #6 had a partially supporting MSCI score in spring 2000 and fall 2005, which indicated the river system may have a more dynamic macroinvertebrate community fluctuating between periods of high and low taxonomic richness. Three of the MSCI metrics contributed to a lower EFBR #6 score during the spring 2000 and fall 2005 including TR, EPTT, and BI. A total of 22 samples have been collected during the spring season from biological reference streams in the Ozark/Black/Current EDU, and seven of

these were collected during the year 2000. Four of these seven streams had partially supporting MSCI scores including Big Creek (Shannon County), Blair Creek (Shannon County), EFBR #6 (Reynolds County), and Sinking Creek (Reynolds County). Lower MSCI score calculations from Big Creek, Blair Creek, and Sinking Creek were attributed to TR, EPTT, and SDI metrics. Water levels did not appear to relate to lower MSCI scores as one stream with the lowest discharge of the group had a fully supporting MSCI score. No other biological reference streams were sampled during the fall 2005 for MSCI seasonal comparison, but samples collected in spring 2000 demonstrate that reference streams occasionally fail to attain fully supporting status.

The macroinvertebrate community at station EFBR #6 has consistently had fully supporting MSCI scores since the fall 2008. Thirteen years post Taum Sauk Reservoir failure is within the predicted macroinvertebrate recovery timeline of 25 years given by Hansen and Hayes (2012) on post dam removal recovery, which can be viewed as similar to the catastrophic dam failure that took place on EFBR.

7.0 Summary

The East Fork Black River macroinvertebrate community attained fully supporting MSCI scores at all study sites, with the exception of EFBR #3. The macroinvertebrate community present at EFBR #3 was consistently different from remaining stations (as measured by the QSIT) having the least in common with station EFBR #6. Taxa at EFBR #3 were generally more tolerant than those present at remaining stations, and this station had the greatest percentage of taxa in the BI range of seven or greater. Water physicochemistry at EFBR stations had elevated turbidity and total phosphorus levels, which peaked at EFBR #3. Habitat assessment total scores among all stations were high and classified as able to support biological communities comparable to the BIOREF stream.

8.0 Conclusions

- H₁: Habitat scores will not differ among stations.
This hypothesis was supported. Stations were all supporting of the biota.
- H₂: East Fork Black River habitat scores will not differ from the reference stream habitat.
This hypothesis was supported. All station habitat scores were at least 75 percent of the biological reference habitat.
- H₃: Physicochemical parameters will not differ among stations.
This hypothesis was not supported. Nutrients, dissolved oxygen, temperature, flow, and turbidity differed among stations.
- H₄: Physicochemical water quality parameters will meet Missouri WQS.

This hypothesis was supported. No parameters fell beyond thresholds in Missouri WQS.

- H₅: Physicochemical water quality parameters will not exceed EPA nutrient criteria.
This hypothesis was not supported. Turbidity and total phosphorus were beyond recommended thresholds set by the EPA at one or more stations of EFBR.
- H₆: The Macroinvertebrate Stream Condition Index (**MSCI**) will indicate benthic communities are similar among stations.
This hypothesis was not supported. Scores for the MSCI varied among EFBR stations and across seasons where partially supporting scores occurred only at EFBR #3.
- H₇: Station MSCI scores will show no improvement over the total period of sample collections.
This hypothesis was generally not supported. Most EFBR station MSCI scores improved or at least remained within the same support category. Station EFBR #6 has historically scored well before scores fell after the reservoir failure. Since then, EFBR #6 has scored well during the past two sampling periods. At EFBR #3, MSCI scores have remained consistently lower with one exception during the fall 2007 where the station was fully supporting.

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Submitted by:

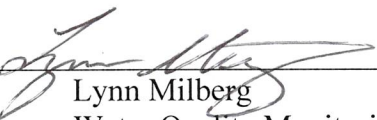


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Appendix A

Fall 2017 East Fork Black River Macroinvertebrate Taxa Lists

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Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #1), Reynolds County, Missouri in the fall 2017. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	33	1	4
AMPHIPODA			
<i>Hyalella azteca</i>			6
BASOMMATOPHORA			
<i>Menetus</i>	2		
COLEOPTERA			
<i>Dubiraphia</i>			5
<i>Microcylloepus pusillus</i>	4	3	18
<i>Optioservus sandersoni</i>	5		
<i>Psephenus herricki</i>	11	5	
<i>Stenelmis</i>	10	44	9
	2		
DECAPODA			
<i>Faxonius hylas</i>	3		
DIPTERA			
<i>Ablabesmyia</i>		6	10
Ceratopogoninae			1
<i>Cladotanytarsus</i>		2	
<i>Corynoneura</i>			2
<i>Cricotopus/Orthocladius</i>	4	6	12
<i>Dicrotendipes</i>		17	2
<i>Dixella</i>			1
<i>Hemerodromia</i>	3		
<i>Labrundinia</i>		1	
<i>Microtendipes</i>		2	
<i>Nanocladius</i>	2	3	2
<i>Parakiefferiella</i>		2	
<i>Paratanytarsus</i>			5
<i>Phaenopsectra</i>		3	
<i>Polypedilum flavum</i>	60	3	3
<i>Polypedilum illinoense</i> grp		1	2
<i>Psectrocladius</i>			3
<i>Pseudochironomus</i>		6	
<i>Rheocricotopus</i>	1		
<i>Rheotanytarsus</i>	56	6	13
<i>Simulium</i>	16		2

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Stelechomyia</i>			1
<i>Stempellinella</i>	3	12	1
<i>Stenochironomus</i>	1	2	1
<i>Tabanus</i>	*		
<i>Tanytarsus</i>	9	45	25
<i>Thienemanniella</i>	3		2
<i>Thienemannimyia</i> grp.	4	4	2
EPHEMEROPTERA			
<i>Acerpenna</i>			2
<i>Baetis</i>	5		
<i>Baetisca lacustris</i>	1		
<i>Caenis anceps</i>	15	8	4
<i>Caenis latipennis</i>		2	88
<i>Choroterpes</i>		1	
<i>Eurylophella</i>	1		
<i>Isonychia bicolor</i>	32		1
<i>Leucrocuta</i>	14	4	
<i>Maccaffertium bednariki</i>	5		
<i>Maccaffertium mediopunctatum</i>	59	2	
<i>Maccaffertium pulchellum</i>	16		
<i>Maccaffertium terminatum</i>	12		
<i>Plauditus</i>	3	9	2
<i>Procloeon</i>	1	4	1
<i>Stenacron</i>	6	9	
<i>Stenonema femoratum</i>	1	9	1
<i>Tricorythodes</i>	15	5	4
LUMBRICINA			
<i>Lumbricina</i>	4	1	
MEGALOPTERA			
<i>Corydalus</i>	9		
ODONATA			
<i>Argia</i>	33	44	4
<i>Boyeria</i>			1
Gomphidae	1		
<i>Hagenius brevistylus</i>	1	9	
PLECOPTERA			
<i>Agnetina flavescens</i>	2		
<i>Neoperla</i>	6	6	
<i>Perlesta</i>	3		
TRICHOPTERA			
<i>Ceratopsyche morosa</i> grp	1		

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Cheumatopsyche</i>	25	3	1
<i>Chimarra</i>	41		
<i>Helicopsyche</i>	44	1	
<i>Hydroptila</i>	2		
<i>Oecetis</i>	6	7	17
<i>Oxyethira</i>		1	6
<i>Polycentropus</i>		3	2
<i>Setodes</i>	2		
<i>Triaenodes</i>			2
TRICLADIDA			
Planariidae	5		

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Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #2), Reynolds County, Missouri in the fall 2017. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	17	18	86
AMPHIPODA			
<i>Hyalella azteca</i>			88
BASOMMATOPHORA			
Ancylidae	1		
<i>Menetus</i>		2	2
<i>Physella</i>			2
COLEOPTERA			
<i>Dubiraphia</i>		6	6
<i>Microcylloepus pusillus</i>	2		6
<i>Psephenus herricki</i>	25	1	1
<i>Stenelmis</i>	120	30	10
DECAPODA			
<i>Faxonius hylas</i>	1		
DIPTERA			
<i>Ablabesmyia</i>		12	11
<i>Atherix</i>	*		
<i>Cardiocladius</i>	1		
Ceratopogoninae		2	
<i>Chelifera</i>	2		
Chironomidae	1	1	
<i>Chironomus</i>		1	
<i>Cladopelma</i>		2	
<i>Cladotanytarsus</i>		19	2
<i>Corynoneura</i>		1	2
<i>Cricotopus/Orthocladius</i>	6		
<i>Cryptochironomus</i>	1	4	
<i>Dicrotendipes</i>	1	6	6
<i>Dixella</i>			3
Forcipomyiinae	1		
<i>Nanocladius</i>	1	1	13
<i>Paratanytarsus</i>			3
<i>Phaenopsectra</i>		1	1
<i>Polypedilum flavum</i>	19		1
<i>Polypedilum illinoense</i> grp	1		1
<i>Polypedilum scalaenum</i> grp		2	
<i>Procladius</i>		5	

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Pseudochironomus</i>		5	4
<i>Rheotanytarsus</i>	14		
<i>Simulium</i>	1		
<i>Stempellina</i>		4	
<i>Stempellinella</i>		14	1
<i>Stenochironomus</i>			1
<i>Stictochironomus</i>		19	
<i>Tanytarsus</i>	13	40	14
<i>Thienemannimyia</i> grp.	1		2
<i>Tribelos</i>		2	
EPHEMEROPTERA			
<i>Acentrella</i>	1		
<i>Anthopotamus</i>	1		
<i>Baetis</i>	1		
<i>Baetisca lacustris</i>		1	
<i>Caenis anceps</i>	28	10	1
<i>Caenis latipennis</i>		2	22
<i>Centroptilum</i>		6	5
<i>Choroterpes</i>		5	
<i>Ephemera simulans</i>		1	
<i>Isonychia bicolor</i>	26		
Leptophlebiidae	2		
<i>Leucrocuta</i>	9		
<i>Maccaffertium mediopunctatum</i>	33		2
<i>Maccaffertium pulchellum</i>	33	4	
<i>Plauditus</i>	9		
<i>Procloeon</i>	1	3	2
<i>Stenacron</i>	27	2	
<i>Stenonema femoratum</i>	2	23	4
<i>Tricorythodes</i>	28		
LUMBRICINA			
<i>Lumbricina</i>	2		1
MEGALOPTERA			
<i>Corydalus</i>	2		
ODONATA			
<i>Argia</i>	43	2	5
<i>Basiaeschna janata</i>			1
<i>Enallagma</i>		1	8
Gomphidae	1		
<i>Macromia</i>		1	
<i>Stylogomphus albistylus</i>		*	

ORDER: TAXA	Habitat		
	CS	NF	RM
PLECOPTERA			
<i>Acroneuria</i>	1		
<i>Agneta flavescens</i>	1		
<i>Neoperla</i>	28	5	
TRICHOPTERA			
<i>Ceratopsyche morosa</i> grp	2		
<i>Cheumatopsyche</i>	33		
<i>Chimarra</i>	26		
<i>Helicopsyche</i>	24		
<i>Mystacides</i>		2	
<i>Nectopsyche</i>	1		
<i>Oecetis</i>	6		1
<i>Oxyethira</i>			1
<i>Polycentropus</i>	1	1	2
<i>Setodes</i>	1		
<i>Triaenodes</i>			5
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Tubificidae		4	
VENEROIDA			
<i>Corbicula</i>	4	1	

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ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	1	5	18
AMPHIPODA			
<i>Hyalella azteca</i>			18
BASOMMATOPHORA			
<i>Menetus</i>		1	4
COLEOPTERA			
<i>Microcylloepus pusillus</i>	2		21
<i>Psephenus herricki</i>		2	
<i>Stenelmis</i>	50	21	7
DECAPODA			
<i>Faxonius hylas</i>	*	*	
<i>Faxonius virilis</i>			*
DIPTERA			
<i>Ablabesmyia</i>		1	9
Ceratopogoninae		1	
<i>Chironomus</i>		2	
<i>Cricotopus bicinctus</i>			1
<i>Cricotopus/Orthocladius</i>			30
<i>Dicrotendipes</i>		2	6
<i>Hemerodromia</i>	1		
<i>Nanocladius</i>	2		
<i>Nilothauma</i>			1
<i>Paratanytarsus</i>	2	1	11
<i>Phaenopsectra</i>			1
<i>Polypedilum flavum</i>	60		3
<i>Polypedilum illinoense</i> grp	5		3
<i>Polypedilum scalaenum</i> grp			2
<i>Procladius</i>		1	
<i>Rheotanytarsus</i>	1	1	6
<i>Simulium</i>	1		
<i>Stenochironomus</i>			1
<i>Tanytarsus</i>		5	5
<i>Thienemanniella</i>	1		
EPHEMEROPTERA			
<i>Acentrella</i>	1		
<i>Baetis</i>	4		
<i>Caenis anceps</i>	9		

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Caenis latipennis</i>		123	63
<i>Centroptilum</i>		2	
<i>Hexagenia</i>		4	
<i>Isonychia bicolor</i>	47		
Leptophlebiidae		8	
<i>Maccaffertium mediopunctatum</i>	28		
<i>Maccaffertium pulchellum</i>	8		
<i>Maccaffertium terminatum</i>	1		
<i>Procloeon</i>		4	
<i>Stenacron</i>	1	16	
<i>Stenonema femoratum</i>		109	2
<i>Tricorythodes</i>	282	1	70
LUMBRICINA			
<i>Lumbricina</i>	8	1	
MEGALOPTERA			
<i>Corydalus</i>	10		
ODONATA			
<i>Argia</i>	3	10	1
<i>Calopteryx</i>			2
<i>Enallagma</i>			4
<i>Macromia</i>		1	
PLECOPTERA			
<i>Agnetina flavescens</i>	3	*	
<i>Neoperla</i>	10		
TRICHOPTERA			
<i>Ceratopsyche</i>	4		
<i>Cheumatopsyche</i>	76		2
<i>Chimarra</i>	104		1
<i>Hydropsyche</i>	2		
<i>Oecetis</i>		1	10
<i>Oxyethira</i>			1
<i>Polycentropus</i>		1	3
<i>Triaenodes</i>			8
TRICLADIDA			
Planariidae	63		
VENEROIDA			
<i>Corbicula</i>	26	1	1

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Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #6), Reynolds County, Missouri in the fall 2017. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	7	1	2
AMPHIPODA			
<i>Hyalella azteca</i>			55
BASOMMATOPHORA			
<i>Menetus</i>		5	2
<i>Physella</i>			5
COLEOPTERA			
<i>Dubiraphia</i>		12	7
<i>Ectopria nervosa</i>		3	2
<i>Microcylloepus pusillus</i>			16
<i>Optioservus sandersoni</i>	7		
<i>Psephenus herricki</i>	19	4	
<i>Stenelmis</i>	185	19	15
DECAPODA			
<i>Faxonius virilis</i>			*
DIPTERA			
<i>Ablabesmyia</i>		7	20
<i>Cardiocladius</i>	1		
Ceratopogoninae		1	
Chironomidae		1	
<i>Chironomus</i>		4	
<i>Cladotanytarsus</i>		4	1
<i>Cricotopus bicinctus</i>			3
<i>Cricotopus/Orthocladius</i>	6		2
<i>Cryptochironomus</i>		5	
<i>Dicrotendipes</i>		2	2
<i>Hemerodromia</i>			2
<i>Labrundinia</i>			1
<i>Microtendipes</i>			2
<i>Nilotanypus</i>	1		
<i>Nilothauma</i>			1
<i>Paratanytarsus</i>			9
<i>Paratendipes</i>		1	
<i>Polypedilum aviceps</i>	1		
<i>Polypedilum flavum</i>	13		
<i>Polypedilum halterale</i> grp		1	
<i>Polypedilum illinoense</i> grp			2

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Polypedilum scalaenum</i> grp		2	
<i>Procladius</i>		1	
<i>Psectrocladius</i>			3
<i>Pseudochironomus</i>			1
<i>Rheotanytarsus</i>	10		7
<i>Simulium</i>	2		
<i>Stempellinella</i>	2	1	3
<i>Stictochironomus</i>		2	
<i>Tabanus</i>	4		
<i>Tanytarsus</i>	6	8	20
<i>Thienemanniella</i>	2		
<i>Thienemannimyia</i> grp.	3	2	14
<i>Tribelos</i>		113	8
EPHEMEROPTERA			
<i>Acerpenna</i>	2		
<i>Baetis</i>	6		
<i>Caenis anceps</i>	28		
<i>Caenis latipennis</i>		25	23
<i>Centroptilum</i>			3
<i>Eurylophella</i>			1
<i>Heptageniidae</i>	9		
<i>Hexagenia</i>		5	1
<i>Isonychia bicolor</i>	64		
<i>Leptophlebiidae</i>		5	1
<i>Leucrocuta</i>	23		
<i>Maccaffertium bednariki</i>	2		
<i>Maccaffertium mediopunctatum</i>	36		
<i>Maccaffertium pulchellum</i>	61	2	1
<i>Plauditus</i>	4		
<i>Procloeon</i>		2	
<i>Stenacron</i>	5	1	1
<i>Stenonema femoratum</i>		44	5
<i>Tricorythodes</i>	4	1	6
HEMIPTERA			
<i>Rheumatobates</i>			1
Veliidae	1		
ISOPODA			
<i>Caecidotea</i>	1		1
LEPIDOPTERA			
<i>Petrophila</i>	1		
LUMBRICINA			

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Lumbricina</i>	8	1	
MEGALOPTERA			
<i>Corydalus</i>	4		
ODONATA			
<i>Argia</i>	2	2	4
<i>Calopteryx</i>			1
<i>Enallagma</i>			16
Gomphidae	4	1	1
<i>Hagenius brevistylus</i>	2		1
<i>Hetaerina</i>			9
<i>Stylogomphus albistylus</i>		2	
PLECOPTERA			
<i>Agneta flavescens</i>	6		
<i>Neoperla</i>	8		
<i>Perlesta</i>		2	
TRICHOPTERA			
<i>Cheumatopsyche</i>	14		
<i>Chimarra</i>	5		
<i>Helicopsyche</i>	14		25
<i>Nectopsyche</i>			10
<i>Oecetis</i>	3		3
<i>Oxyethira</i>			3
<i>Polycentropus</i>		1	1
<i>Triaenodes</i>			11
TRICLADIDA			
Planariidae	2		8
TUBIFICIDA			
Tubificidae		1	

Appendix B

Spring 2018 East Fork Black River Macroinvertebrate Taxa Lists

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Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #1a), Reynolds County, Missouri in the spring 2018. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	10	6	3
AMPHIPODA			
<i>Hyalella azteca</i>		2	5
<i>Stygobromus</i>		2	
BASOMMATOPHORA			
Lymnaeidae			1
<i>Physella</i>			1
COLEOPTERA			
<i>Dubiraphia</i>		9	2
<i>Microcylloepus pusillus</i>	2	3	6
<i>Optioservus sandersoni</i>	1		
<i>Psephenus herricki</i>	1	1	
<i>Stenelmis</i>	200	79	
DECAPODA			
<i>Faxonius punctimanus</i>			*
DIPTERA			
<i>Ablabesmyia</i>		4	
<i>Cardiocladius</i>	1		
Ceratopogoninae		7	
<i>Cladotanytarsus</i>		7	
<i>Clinocera</i>	2	1	
<i>Cricotopus bicinctus</i>			9
<i>Cricotopus/Orthocladius</i>	22	25	74
<i>Cryptochironomus</i>		1	
<i>Eukiefferiella</i>	5		
<i>Hemerodromia</i>	7	2	
<i>Hexatoma</i>		*	
<i>Labrundinia</i>			1
<i>Micropsectra</i>	1	5	
<i>Microtendipes</i>	7		
<i>Orthocladius (Euorthocladius)</i>	3		1
<i>Pagastiella</i>		1	
<i>Parakiefferiella</i>		4	
<i>Parametriocnemus</i>	8	2	
<i>Paratanytarsus</i>		6	4
<i>Phaenopsectra</i>		5	
<i>Polypedilum aviceps</i>	2		

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Polypedilum flavum</i>	5		
<i>Procladius</i>		1	
<i>Prosimulium</i>	3		
<i>Psectrocladius</i>		1	
<i>Pseudochironomus</i>		2	
<i>Rheocricotopus</i>			1
<i>Rheotanytarsus</i>	12	3	16
<i>Simulium</i>	19		
<i>Stempellinella</i>	5	11	2
<i>Synorthocladius</i>		3	
<i>Tanytarsus</i>	6	29	4
<i>Thienemanniella</i>			4
<i>Thienemannimyia</i> grp.	6	10	8
<i>Tipula</i>		*	
EPHEMEROPTERA			
<i>Caenis anceps</i>	1	37	1
<i>Caenis latipennis</i>		17	31
<i>Ephemerella</i>		1	
<i>Ephemerella invaria</i>	22		1
<i>Eurylophella</i>	1		
<i>Eurylophella bicolor</i>		5	
<i>Eurylophella enoensis</i>			3
<i>Fallceon</i>			1
<i>Isonychia bicolor</i>	74		6
<i>Leptophlebia</i>			2
<i>Leucrocuta</i>	1		
<i>Maccaffertium bednariki</i>	10		
<i>Maccaffertium mediopunctatum</i>	37	2	
<i>Maccaffertium pulchellum</i>	6		6
<i>Siphonurus</i>			1
<i>Stenonema femoratum</i>	2	21	5
<i>Tricorythodes</i>	3	1	3
ISOPODA			
<i>Lirceus</i>		1	2
LUMBRICINA			
<i>Lumbricina</i>	10	4	
LUMBRICULIDA			
Lumbriculidae	1	1	
MEGALOPTERA			
<i>Corydalus</i>	3	*	
ODONATA			

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Argia</i>		5	
<i>Basiaeschna janata</i>			*
<i>Boyeria</i>			2
<i>Enallagma</i>		1	1
<i>Hagenius brevistylus</i>			1
PLECOPTERA			
<i>Agneta flavescens</i>	2		
<i>Helopis nalatus</i>	*		
<i>Isoperla</i>	6		
<i>Neoperla</i>	15	6	
Perlidae			7
<i>Perlinella ephyre</i>	3	3	
<i>Prostoia</i>	6		2
TRICHOPTERA			
<i>Ceratopsyche</i>	3		
<i>Cheumatopsyche</i>	17	2	1
<i>Chimarra</i>	12		
<i>Helicopsyche</i>	1		
<i>Hydroptila</i>			16
<i>Oecetis</i>		1	3
<i>Oxyethira</i>			44
<i>Polycentropus</i>		4	1
<i>Pycnopsyche</i>			1
<i>Triaenodes</i>			5
TRICLADIDA			
Planariidae	25	1	

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ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	3	8	
AMPHIPODA			
<i>Hyalella azteca</i>		3	3
BASOMMATOPHORA			
<i>Physella</i>			2
COLEOPTERA			
<i>Dineutus</i>			*
<i>Dubiraphia</i>		12	4
<i>Lutrochus</i>	1		
<i>Microcylloepus pusillus</i>		4	9
<i>Optioservus sandersoni</i>	3		
<i>Stenelmis</i>	213	31	1
DECAPODA			
<i>Faxonius virilis</i>		*	
DIPTERA			
<i>Ablabesmyia</i>		4	1
Ceratopogoninae		3	
<i>Cladotanytarsus</i>	1	10	
<i>Clinocera</i>	2		
<i>Corynoneura</i>			1
<i>Cricotopus bicinctus</i>	3		15
<i>Cricotopus/Orthocladius</i>	13	40	109
<i>Cryptochironomus</i>		1	
<i>Dicrotendipes</i>		1	2
<i>Eukiefferiella</i>	9		
<i>Hemerodromia</i>	5	2	3
<i>Hexatoma</i>	1		
<i>Labrundinia</i>			1
<i>Microtendipes</i>	2	5	
<i>Nanocladius</i>	2	1	1
<i>Nilothauma</i>		1	
<i>Orthocladius (Euorthocladius)</i>	2	1	1
<i>Pagastiella</i>		1	
<i>Parakiefferiella</i>		3	
<i>Parametriocnemus</i>	11	2	
<i>Paratanytarsus</i>		3	10
<i>Phaenopsectra</i>		2	

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Polypedilum aviceps</i>	4		
<i>Polypedilum flavum</i>	1		
<i>Prosimulium</i>	5		
<i>Psectrocladius</i>	1		2
<i>Pseudochironomus</i>		1	
<i>Rheotanytarsus</i>	10	7	26
<i>Simulium</i>	12		
<i>Stempellinella</i>	2	10	
<i>Stenochironomus</i>			1
<i>Stictochironomus</i>		1	
<i>Tabanus</i>	*		
<i>Tanytarsus</i>	5	29	5
<i>Thienemanniella</i>			1
<i>Thienemannimyia</i> grp.	6	12	12
<i>Tvetenia</i>	1		
<i>Zavrelimyia (Paramerina)</i>			2
EPHEMEROPTERA			
<i>Acentrella</i>	2		
<i>Caenis anceps</i>	3		
<i>Caenis latipennis</i>		12	13
<i>Ephemerella invaria</i>	12		
<i>Eurylophella</i>	2		
<i>Eurylophella bicolor</i>		10	4
Heptageniidae	2		
<i>Isonychia bicolor</i>	85		3
Leptophlebiidae			1
<i>Leucrocuta</i>	2		
<i>Maccaffertium bednariki</i>	13		
<i>Maccaffertium mediopunctatum</i>	23		
<i>Maccaffertium pulchellum</i>	4		4
<i>Serratella serratoides</i>			2
<i>Stenonema femoratum</i>	6	11	3
<i>Tricorythodes</i>	1	2	1
ISOPODA			
<i>Lirceus</i>		3	
LUMBRICINA			
<i>Lumbricina</i>	18	1	
LUMBRICULIDA			
Lumbriculidae	3	1	
MEGALOPTERA			
<i>Corydalus</i>	5		

ORDER: TAXA	Habitat		
	CS	NF	RM
ODONATA			
<i>Argia</i>	2	1	
<i>Enallagma</i>		1	2
PLECOPTERA			
<i>Acroneuria</i>	1	*	1
<i>Agneta flavescens</i>	2		
<i>Amphinemura</i>	1		1
<i>Isoperla</i>	2		
<i>Neoperla</i>	12	8	
<i>Perlidae</i>	3		7
<i>Prostoia</i>	4		
<i>Zealeuctra</i>		1	1
TRICHOPTERA			
<i>Agapetus</i>	1		
<i>Ceratopsyche morosa</i> grp	2		
<i>Cheumatopsyche</i>	11	1	1
<i>Chimarra</i>	15		
<i>Helicopsyche</i>	3		6
<i>Hydroptila</i>		3	10
<i>Nectopsyche</i>			1
<i>Oecetis</i>		1	1
<i>Oxyethira</i>		2	31
<i>Polycentropus</i>		1	2
<i>Pycnopsyche</i>			*
<i>Triaenodes</i>			1
TRICLADIDA			
Planariidae	4		
VENEROIDA			
Corbicula		1	

Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #2), Reynolds County, Missouri in the spring 2018. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	4	9	29
AMPHIPODA			
<i>Hyalella azteca</i>		9	87
BASOMMATOPHORA			
Ancylidae		1	
<i>Menetus</i>		3	3
<i>Physella</i>			*
COLEOPTERA			
<i>Dubiraphia</i>		3	5
Dytiscidae		1	
<i>Helichus fastigiatus</i>			2
<i>Microcylloepus pusillus</i>	4		
<i>Optioservus sandersoni</i>	1		
<i>Psephenus herricki</i>	4	*	
<i>Stenelmis</i>	112	20	4
DECAPODA			
<i>Faxonius hylas</i>		1	*
<i>Faxonius punctimanus</i>			1
DIPTERA			
<i>Ablabesmyia</i>		6	6
<i>Cardiocladius</i>	3		
Ceratopogoninae	2	9	1
Chironomidae		4	
<i>Cladotanytarsus</i>		9	1
<i>Corynoneura</i>			1
<i>Cricotopus bicinctus</i>	4		8
<i>Cricotopus/Orthocladius</i>	58	3	44
<i>Cryptochironomus</i>		5	
<i>Dicrotendipes</i>		8	3
<i>Eukiefferiella</i>	3		
<i>Hemerodromia</i>	13	1	
<i>Labrundinia</i>		1	2
<i>Micropsectra</i>	1	1	
<i>Microtendipes</i>	13		
<i>Nanocladius</i>	9	1	
<i>Orthocladius (Euorthocladius)</i>	1		
<i>Parakiefferiella</i>		10	

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Parametriocnemus</i>	9	1	
<i>Paratanytarsus</i>	1	1	7
<i>Phaenopsectra</i>			1
<i>Polypedilum aviceps</i>	3		
<i>Polypedilum flavum</i>	1		
<i>Potthastia</i>			1
<i>Procladius</i>		10	
<i>Prosimulium</i>	3		
<i>Psectrocladius</i>		2	1
<i>Pseudorthocladius</i>			1
<i>Rheocricotopus</i>	1		
<i>Rheotanytarsus</i>	14		2
<i>Simulium</i>	3		
<i>Stempellinella</i>	12	17	6
<i>Stilocladius</i>			1
Stratiomyidae			1
<i>Synorthocladius</i>	1	1	1
<i>Tabanus</i>	2		
<i>Tanytarsus</i>	10	39	15
<i>Thienemannimyia</i> grp.	6	2	1
<i>Tribelos</i>		16	
<i>Zavreliella</i>		5	
EPHEMEROPTERA			
<i>Caenis anceps</i>	15	4	2
<i>Caenis latipennis</i>		7	16
<i>Centroptilum</i>		2	
<i>Ephemera simulans</i>		2	
<i>Ephemerella invaria</i>	16		
<i>Eurylophella bicolor</i>			1
<i>Hexagenia limbata</i>		4	
<i>Isonychia bicolor</i>	67		
<i>Leptophlebia</i>		1	2
<i>Leucrocuta</i>	2		
<i>Maccaffertium bednariki</i>	11	1	
<i>Maccaffertium mediopunctatum</i>	17	1	
<i>Maccaffertium pulchellum</i>	32	4	
<i>Maccaffertium terminatum</i>	4		
<i>Serratella</i>	2		
<i>Siphonurus</i>		1	1
<i>Stenacron</i>	3		
<i>Stenonema femoratum</i>	11	1	7

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Tricorythodes</i>	28		
ISOPODA			
<i>Caecidotea</i> (Blind & Unpigmented)		4	
LEPIDOPTERA			
<i>Petrophila</i>	3		
LUMBRICINA			
<i>Lumbricina</i>	24	1	1
LUMBRICULIDA			
Lumbriculidae		1	
MEGALOPTERA			
<i>Corydalus</i>	3		
ODONATA			
<i>Argia</i>	12	2	5
<i>Enallagma</i>			3
<i>Stylogomphus albistylus</i>	1		
PLECOPTERA			
<i>Agnetina flavescens</i>	4		
<i>Neoperla</i>	24	6	1
<i>Perlesta</i>			1
<i>Perlidae</i>		1	
<i>Prostoia</i>	1		
TRICHOPTERA			
<i>Ceratopsyche</i>	7		
<i>Cheumatopsyche</i>	48		
<i>Chimarra</i>	18		
<i>Helicopsyche</i>	27	1	
<i>Hydroptila</i>	3		
<i>Lepidostoma</i>	1		
<i>Oecetis</i>	1		
<i>Polycentropus</i>		2	3
<i>Triaenodes</i>			2
TRICLADIDA			
Planariidae	4	1	
TUBIFICIDA			
<i>Limnodrilus hoffmeisteri</i>		2	1
Tubificidae		2	3
VENEROIDA			
<i>Corbicula</i>	4	3	

Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #3), Reynolds County, Missouri in the spring 2018. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina		7	11
AMPHIPODA			
<i>Hyalella azteca</i>		3	41
ARHYNCHOBDELLIDA			
Erpobdellidae		5	
BASOMMATOPHORA			
Ancylidae			3
<i>Menetus</i>		1	3
COLEOPTERA			
<i>Berosus</i>		1	
<i>Dubiraphia</i>	1		1
<i>Microcylloepus pusillus</i>			2
<i>Optioservus sandersoni</i>	1		
<i>Psephenus herricki</i>	1		
Scirtidae			1
<i>Stenelmis</i>	150	31	7
DECAPODA			
<i>Cambarus hubbsi</i>	1		
<i>Faxonius hylas</i>		*	*
DIPTERA			
<i>Ablabesmyia</i>		26	7
Ceratopogoninae		5	
Chironomidae	2	1	1
<i>Chironomus</i>		1	
<i>Cladotanytarsus</i>		2	
<i>Cricotopus bicinctus</i>	1		
<i>Cricotopus/Orthocladius</i>	46	21	29
<i>Cryptochironomus</i>		6	
<i>Dicrotendipes</i>		9	16
<i>Dixella</i>			2
<i>Eukiefferiella</i>	3		
<i>Hemerodromia</i>	1		
<i>Microtendipes</i>	1	4	
<i>Nanocladius</i>			3
<i>Orthocladius (Euorthocladius)</i>	1		
<i>Parakiefferiella</i>		2	
<i>Paratanytarsus</i>		4	25

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Pericoma</i>			1
<i>Polypedilum aviceps</i>	2		
<i>Polypedilum fallax</i> grp			1
<i>Polypedilum flavum</i>	22		
<i>Polypedilum scalaenum</i> grp		1	
<i>Potthastia</i>		1	1
<i>Prosimulium</i>	8		
<i>Psectrocladius</i>		1	2
<i>Pseudochironomus</i>		3	1
<i>Rheocricotopus</i>	1		
<i>Rheotanytarsus</i>	11	3	1
<i>Simulium</i>	3		2
<i>Stempellinella</i>	3	17	2
<i>Sympotthastia</i>	2		2
<i>Synorthocladius</i>		2	
<i>Tabanus</i>	*		
<i>Tanytarsus</i>	5	37	3
<i>Thienemanniella</i>		1	2
<i>Thienemannimyia</i> grp.	4	3	3
<i>Tipula</i>	1		
<i>Tribelos</i>		13	
<i>Zavreliomyia</i>		1	1
<i>Zavreliomyia (Paramerina)</i>		1	1
EPHEMEROPTERA			
<i>Caenis latipennis</i>	3	41	60
<i>Centroptilum</i>			2
<i>Eurylophella bicolor</i>			1
<i>Eurylophella enoensis</i>		1	
<i>Isonychia bicolor</i>	41	1	6
<i>Leptophlebia</i>			1
<i>Maccaffertium mediopunctatum</i>	6		
<i>Maccaffertium pulchellum</i>	7		2
<i>Stenacron</i>	1	2	
<i>Stenonema femoratum</i>	*	30	4
<i>Tricorythodes</i>	88	2	5
HEMIPTERA			
<i>Ranatra kirkaldyi</i>			1
LUMBRICINA			
<i>Lumbricina</i>	5	8	
MEGALOPTERA			
<i>Corydalus</i>	6		

ORDER: TAXA	Habitat		
	CS	NF	RM
ODONATA			
<i>Argia</i>	1	1	
<i>Enallagma</i>		2	10
<i>Macromia</i>		*	
PLECOPTERA			
<i>Agneta flavescens</i>	2		
<i>Helopis natus</i>	*		
<i>Isoperla</i>	2		
<i>Neoperla</i>	4	3	
<i>Perlinella drymo</i>		1	
<i>Perlinella ephyre</i>		1	
<i>Strophopteryx cucullata</i>	2		
TRICHOPTERA			
<i>Cheumatopsyche</i>	33		
<i>Chimarra</i>	33		
<i>Cyrnellus fraternus</i>		1	
<i>Hydroptila</i>	1		6
<i>Oecetis</i>			2
<i>Polycentropus</i>			4
<i>Triaenodes</i>			5
TRICLADIDA			
Planariidae	73		
TUBIFICIDA			
Tubificidae		1	
VENEROIDA			
<i>Corbicula</i>	10	1	*

Semi-quantitative kick net collections of macroinvertebrates from East Fork Black River (EFBR #6), Reynolds County, Missouri in the spring 2018. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

ORDER: TAXA	Habitat		
	CS	NF	RM
"HYDRACARINA"			
Acarina	1	1	
AMPHIPODA			
<i>Hyalella azteca</i>		1	15
BASOMMATOPHORA			
<i>Menetus</i>	1		2
<i>Physella</i>			1
BRANCHIOBDELLIDA			
<i>Branchiobdellida</i>	1	1	
COLEOPTERA			
<i>Dubiraphia</i>		2	2
<i>Ectopria nervosa</i>			1
<i>Helichus lithophilus</i>			1
<i>Optioservus sandersoni</i>		1	1
<i>Psephenus herricki</i>	2		
<i>Stenelmis</i>	67	16	2
DECAPODA			
<i>Faxonius hylas</i>	1		*
DIPTERA			
<i>Ablabesmyia</i>		11	1
<i>Brillia</i>			1
Ceratopogonidae		1	
Chironomidae	2		1
<i>Cladotanytarsus</i>		6	1
<i>Clinocera</i>	1		
<i>Corynoneura</i>			4
<i>Cricotopus bicinctus</i>	1		
<i>Cricotopus/Orthocladius</i>	36	3	74
<i>Cryptochironomus</i>		3	
<i>Dicrotendipes</i>		2	3
<i>Diptera</i>	1		
<i>Eukiefferiella</i>	5	1	2
<i>Hemerodromia</i>	4		1
<i>Micropsectra</i>	3		
<i>Microtendipes</i>	1	2	1
<i>Nanocladius</i>	1		
<i>Natarsia</i>		1	
<i>Orthocladius (Euorthocladius)</i>	5		

ORDER: TAXA	Habitat		
	CS	NF	RM
<i>Parakiefferiella</i>		1	
<i>Parametriocnemus</i>	5		1
<i>Paratanytarsus</i>		2	17
<i>Paratendipes</i>		1	
<i>Phaenopsectra</i>		1	
<i>Polypedilum aviceps</i>	91	3	6
<i>Polypedilum flavum</i>			1
<i>Polypedilum illinoense</i> grp			1
<i>Polypedilum scalaenum</i> grp		8	
<i>Potthastia</i>	1	1	
<i>Prosimulium</i>	82		5
<i>Psectrocladius</i>			1
<i>Rheocricotopus</i>	3		
<i>Rheotanytarsus</i>	5		5
<i>Simulium</i>	8		
<i>Stempellinella</i>	2	4	1
<i>Stictochironomus</i>		1	1
<i>Sympotthastia</i>	1		4
<i>Tabanus</i>	2	1	
<i>Tanytarsus</i>	11	11	3
<i>Thienemanniella</i>	3		2
<i>Thienemannimyia</i> grp.	9	16	19
<i>Tipula</i>	2		
<i>Tribelos</i>		1	
<i>Tvetenia bavarica</i> grp	5		
<i>Zavreliomyia</i>		4	1
EPHEMEROPTERA			
<i>Acerpenna</i>	2		
<i>Caenis latipennis</i>	5	21	37
<i>Ephemera simulans</i>		1	
<i>Ephemerella invaria</i>	1	1	
<i>Eurylophella bicolor</i>	1		3
<i>Eurylophella enoensis</i>		1	6
Heptageniidae	22	5	
<i>Isonychia bicolor</i>	30		
<i>Leptophlebia</i>		1	
<i>Maccaffertium mediopunctatum</i>	9		
<i>Maccaffertium pulchellum</i>	61		2
<i>Maccaffertium terminatum</i>			1
<i>Stenacron</i>		5	
<i>Stenonema femoratum</i>		9	15

ORDER: TAXA	Habitat		
	CS	NF	RM
ISOPODA			
<i>Lirceus</i>	1		4
LUMBRICINA			
<i>Lumbricina</i>	*		
LUMBRICULIDA			
Lumbriculidae	2		
MEGALOPTERA			
<i>Corydalus</i>	1		
ODONATA			
<i>Argia</i>		2	
<i>Boyeria</i>			1
<i>Calopteryx</i>			1
<i>Helocordulia</i>		1	
<i>Hetaerina</i>		1	
<i>Stylogomphus albistylus</i>		1	1
PLECOPTERA			
<i>Agnetina flavescens</i>	3		
<i>Amphinemura</i>	10		7
<i>Isoperla</i>	3		
Leuctridae	2	1	
<i>Neoperla</i>	19	3	
Perlidae			1
<i>Perlinella ephyre</i>		3	
<i>Prostoia</i>	1		
TRICHOPTERA			
<i>Ceratopsyche</i>	5		
<i>Cheumatopsyche</i>	40	2	2
<i>Chimarra</i>	1		
<i>Helicopsyche</i>	3		5
<i>Hydroptila</i>			6
<i>Lepidostoma</i>	1		
<i>Ochrotrichia</i>			2
<i>Oecetis</i>			6
<i>Oxyethira</i>			1
<i>Polycentropus</i>	2	4	1
<i>Pycnopsyche</i>		*	2
<i>Triaenodes</i>			6
TRICLADIDA			
Planariidae	3		

ORDER: TAXA	Habitat		
	CS	NF	RM
TUBIFICIDA			
Enchytraeidae		1	